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DEVELOPMENT OF ANALYTICAL TECHNIQUES FOR MEASURING AMBIENT ATMOSPHERIC CARCINOGENIC VAPORS

Edo D. Pellizzari

Research Triangle Institute

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DEVELOPMENT OF ANALYTICAL TECHNIQUES FOR MEASURING AMBIENT ATMOSPHERIC CARCINOGENIC VAPORS

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ABSTRACT

Analytical techniques and instrumentation, developed during the previous contract year, were perfected and evaluated for the collection and analysis of carcinogenic and mutagenic vapors occurring in ambient air. The areas of investigation included (a) the performance of a sorbent cartridge sampler for hazardous vapors occurring at concentrations of ng/m^3; (b) the design, fabrication, and performance of a portable field sampler; and (c) the identification of hazardous and background pollutants from several geographical areas in the Continental U. S.

CONTENTS

		Page
Abstract		iii
List of Figures		v
List of Tables		vii
Acknowledgements		x
Sections		
I	Conclusions	1
II	Recommendations	3
III	Introduction	5
IV	Program Objectives	9
V	Performance of Sorbent Cartridge Sampler for Hazardous Vapors	10
VI	Design and Performance of a Portable Field Sampler	41
VII	Identification of Hazardous and Background Pollutants from Several Geographical Areas in the Continental U.S.	50
VIII	References	89
IX	Appendix	94

FIGURES

No.		Page
1	Linear regression of the elution volume *vs* temperature for vapors on Tenax GC.	31
2	Relationship between flow rate and theoretical power requirements at various tube diameters and particle size.	43
3	Nutech Model 221-A AC-DC Sampler.	45
4	Map of Houston, Texas and Vicinity depicting sampling sites.	51
5	Map of Los Angeles, CA and Vicinity depicting sampling sites.	52
6	Map of the Kanawha Valley in West Virginia depicting sampling sites.	53
7	Total ion chromatogram of Tenax GC cartridge blank.	60
8	Total ion chromatogram of ambient air sample from South Charleston, WV.	63
9	Total ion chromatogram of ambient air sample from Pasadena, TX.	65
10	Total ion chromatogram of ambient air sample from Pasadena, TX.	67
11	Total ion chromatogram of ambient air sample from Glendora, CA.	69
12	Total ion chromatogram of ambient air sample from Glendora, CA.	71
13	Total ion chromatogram of ambient air sample near Burlington Industries and Mallinckrodt in Raleigh, NC.	82
14	Mass spectrum of chromatographic Peak No. 84 eluting at 194°C for previous figure.	83
15	Mass spectrum of an authentic sample of biphenyl.	84
16	Mass fragmentograms of unique ions representing carbon tetrachloride (m/e 117), tetrachloroethylene (m/e 166) and *m*-dichlorobenzene (m/e 146) in ambient air from Glendora, CA.	86

FIGURES CONT'D

No. Page

17 Mass fragmentograms of unique ions representing methylene chloride (m/e 49) and chloroform (m/e 83) in ambient air from Glendora, CA. 87

18 Total ion current plot during gas-liquid chromatography mass spectrometry of air sample from Santa Monica, CA. 95

19 Total ion current plot during gas-liquid chromatography mass spectrometry of air sample from West Covina, CA. 99

20 Total ion current plot during gas-liquid chromatography mass spectrometry of air sample from Glendora, CA. 107

21 Total ion current plot during gas-liquid chromatography mass spectrometry of air sample from Anaheim, CA. 109

22 Total ion current plot during gas-liquid chromatography mass spectrometry of night air sample from Anaheim, CA. 111

23 Total ion current plot during gas-liquid chromatography mass spectrometry of air samples from Garden Grove, CA. 113

24 Total ion current plot of ambient air sample taken at May Street, Houston, TX. 153

25 Total ion current plot of ambient air sample taken at Shaw Drive, Pasadena, TX. 156

26 Total ion current plot of ambient air sample from Baytown, TX. 159

27 Total ion current plot of ambient air sample taken in Texas City, TX. 161

28 Total ion current plot of ambient air sample taken at Stuebner Airline, Houston, TX. 162

TABLES

No. Page

1 Relationship Between Temperature, Water Vapor Pressure, and Humidity in a Closed Vessel Containing Water. 12

2 Effect of Humidity on Percent Collection Efficiency for Tenax GC. 15

3 Effect of Humidity on Breakthrough Volumes of Hazardous Vapors for Tenax GC. 15

4 Volatile Organic Vapor Mixture for Determining Effect of Repeated Thermal Desorption on Collection Efficiency of Tenax GC. 17

5 Effect of Repeated Desorption on Percent Collection Efficiency of Tenax GC Cartridge Samplers. 18

6 Organic Vapors Employed for Study on the Effect of Transportation and Storage on Sample from Tenax GC. 20

7 Experimental Design for Studying the Effect of Transportation and Storage on Tenax Cartridges. 21

8 Effect of Transportation and Storage on the Percent Recovery of Vapors from Tenax GC Cartridges. 23

9 Effects of Transportation and Storage on the Percent Recovery of Carcinogenic Vapors from Tenax GC. 24

10 Effects of Transportation and Storage on the Percent Recovery of Carcinogenic Vapors from Tenax GC. 25

11 Effects of Transportation and Storage on the Percent Recovery of Carcinogenic Vapors from Tenax GC. 26

12 Composition of Mixtures I and II for Evaluating Sorbent Media. 28

13 Comparison of Collection Efficiency and Breakthrough for Several Sorbents. 29

14 Comparison of Breakthrough Volumes Obtained from Two Different Techniques for Tenax GC. 33

15 Breakthrough Volumes for Several Highly Volatile Compounds on Tenax GC (35/60 Mesh) Cartridges. 34

16 Breakthrough Volumes for Chromosorb 104. 36

17 Comparison of Breakthrough Volumes for Tenax GC and Chromosorb 104. 36

TABLES CONT'D

No.		Page
18	Breakthrough Study of Organic Vapors During Field Sampling.	38
19	Breakthrough Study of Hazardous Vapors During Field Sampling.	39
20	Breakthrough Volume of Hazardous Vapors for Tenax GC (35/60) Obtained During Field Sampling.	40
21	Relationship Between Flow Rate, Pressure Differential, and Cartridge Dimensions for Nutech Model 221-A Portable Samplers (AC Mode).	46
22	Relationship Between Flow Rate, Pressure Differential, and Cartridge Dimensions for Nutech Model 221-A Portable Samplers (DC Mode).	48
23	Performance of Nutech Model 221-A Portable Field Samplers Under Battery Operation.	49
24	Sampling Protocol for Kanawha Valley, W. VA.	55
25	Sampling Protocol for Houston, Texas and Vicinity.	56
26	Sampling Protocol for Los Angeles Basin Area.	57
27	Operating Parameters for GLC-MS-COMP System.	59
28	Halogenated Hydrocarbons Identified in Ambient Air by Capillary Gas-Liquid Chromatography/Mass Spectrometry/ Computer.	73
29	Oxygenated Organic Vapors in Ambient Air by Capillary Gas-Liquid Chromatography/Mass Spectrometry Computer.	75
30	Aromatic Hydrocarbons Identified in Ambient Air by Capillary Gas-Liquid Chromatography/Mass Spectrometry/ Computer.	77
31	Aliphatic Hydrocarbons Detected and/or Identified in Ambient Air by Capillary Gas-Liquid Chromatography/ Mass Spectrometry/Computer.	79
32	Pollutants Identified in Ambient Air from Santa Monica, CA.	97
33	Pollutants Identified in Ambient Air from West Covina, CA.	101
34	Pollutants Identified in Night Ambient Air from West Covina, CA.	104
35	Pollutants Identified in Ambient Air from Santa Monica, CA.	115
36	Pollutants Identified in Ambient Air from West Covina, CA.	118

TABLES CONT'D

No.		Page
37	Pollutants Identified in Ambient Air from Glendora, CA.	121
38	Pollutants Identified in Ambient Air from Garden Grove, CA.	124
39	Pollutants Identified in Ambient Air from Anaheim, CA.	127
40	Pollutants Identified in Night Ambient Air from Santa Monica, CA.	131
41	Pollutants Identified in Night Ambient Air from Anaheim, CA.	136
42	Pollutants Identified in Night Ambient Air from Anaheim, CA.	140
43	Pollutants Identified or Detected in Ambient Air from Santa Monica, CA.	144
44	Pollutants Identified or Detected in Ambient Air from Glendora, CA.	148
45	Pollutants Identified in Ambient Air from May Street in Houston, TX.	154
46	Pollutants Identified in Ambient Air from Pasadena, TX.	157
47	Pollutants Identified in Ambient Air from Baytown, TX.	160
48	Pollutants Identified in Ambient Air from Pasadena, TX.	163
49	Pollutants Identified in Ambient Air from Baytown, TX.	168
50	Pollutants Identified in Ambient Air from Texas City, TX.	171
51	Pollutants Identified in Ambient Air from Pasadena, TX.	176
52	Pollutants in Ambient Air from Dunbar, W. VA.	181
53	Pollutants in Ambient Air from South Charleston, W. VA.	183

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SECTION I

CONCLUSIONS

The performance of sorbents for the collection and analysis of hazardous vapors from ambient air utilizing primarily two criteria, collection efficiency and breakthrough volumes, was studied. Extensive examination of the performance of Tenax sorbent cartridge samplers indicated that (1) there was relatively little effect of humidity on the collection efficiency and breakthrough volumes for acrolein, diethyl sulfate, propylene oxide, methyl ethyl ketone, nitromethane, glycid aldehyde, and bis-(chloromethyl)ether. The collection efficiencies in all cases were quantitative, and the breakthrough volumes were identical to those obtained under arid conditions; (2) the effect of repeated thermal desorption was found not to effect the collection efficiency of Tenax GC even after 15 cycles; (3) the retaining efficiency of Tenax GC for 29 hazardous vapors studied indicated that a decrease in the quantitative recovery (10-30%) had gradually after four weeks of storage; (4) the collective efficiency and breakthrough volumes for several vapors on Tenax GC was related to the molecular structure and volatility of the compound. The lowest breakthrough volume was observed for acrolein (4.5 ℓ/g of Tenax) and the highest for styrene oxide (3.5 m^3/g of sorbent). Comparison of Tenax GC to Chromosorb 104 revealed that Chromosorb 104 had a higher retention index (4-9 times); however, Chromosorb 104 also trapped more water and exhibited a lower temperature stability. Breakthrough studies conducted in areas regarded as to having low and high background pollution levels indicated that displacement of acrolein, trichloroethylene, 2-chloroethyl ethyl ether, bis-(chloromethyl)ether, chlorobenzene, phenyl methyl ether, toluene, and nitrobenzene had not occurred.

Using the criteria and design specifications undercovered during the previous contract period, a portable field sampler was fabricated. The testing of two portable field samplers yielded performance data which were well within the design specifications (6.7 ℓ/min using a 35/60 mesh sorbent in a cartridge 1.5 cm i.d. x 6 cm bed-depth). Portable field samplers operated in the DC mode required 2-2.5 amps depending on the cartridge size, sorbent mesh, and flow rates employed. It was concluded that for a standard 12-V 50 amp-hr battery, the maximum sampling period attainable would be approximately 20 hours.

Many hazardous and background pollutants were identified in three major geographical areas in the Continental United States, the Kanawha Valley, W. VA., Houston, Texas area, and the Los Angeles Basin. A combined total of 21 halogenated compounds were identified. Amongst them were two known carcinogens, vinyl chloride and trichloroethylene. Others may be classified as cocarcinogens (chloroform, carbon tetrachloride, and bromoform). A combined total of 27 oxygenated compounds were identified. Two epoxides (styrene oxide and epoxyheptane) were tentatively characterized. Several aldehydes, ethers, alcohols, ketones, and a phenolic compound were detected. Background constituents which were either identified or detected in ambient air consisted of over 40 aromatic and approximately 113 aliphatic compounds. It was concluded that this may represent only a small percentage of the hazardous pollutants present in the atmosphere. Improved methods of resolution are needed. Future studies should also estimate the quantity of carcinogenic and mutagenic pollutants in ambient air.

SECTION II

RECOMMENDATIONS

Three major phases of research should be expanded and pursued:

(1) Extensive Sampling of Numerous Sites for Hazardous Atmospheric Pollutants -
The methodology for collection, resolution and identification of hazardous vapors in ambient air which was developed and improved during the past two years under Contract No. 68-02-1228, should be applied to field sampling of numerous sites within the Continental U.S. with a major thrust toward the characterization and identification of carcinogenic and mutagenic vapors.

(2) Identification of Hazardous Vapors in Atmospheric Samples - Further research should be undertaken on the resolution of background and hazardous vapors collected at field sites. The resolution and characterization studies of air samples should be achieved by using glc-ms-comp techniques employing a set (3-4) of glass capillary columns of 100-300 m in length containing non-polar, semi-polar and polar stationary phases.

(3) Development of Pollution Profile Indicative of Individual Sites - Pollution profiles should be constructed for the various geographical areas postulated to contain hazardous vapors. These profiles should consist of the following: (a) total ion current plots representative of individual sites sampled based primarily on the hazardous vapors identified; (b) total ion current plots representative of all sites sampled which will include the general background incurred in ambient air; (c) mass fragmentograms representative of individual sites sampled using mass ions characteristic of hazardous vapors, and aliphatic and aromatic compounds, and (d) mass fragmentograms representative of all site samples using mass ions which constitute general background and interferences. In all cases the profiles should be constructed using high resolution capillary columns containing non-polar, semi-polar or polar stationary phases. The chromatographic parameters (carrier flow rates, temperature program rates, etc.) should be standardized for each case so

that comparisons can be made between geographical area, sites, locations and seasons.

(4) Estimation of the Levels of Hazardous Vapors Present in Ambient Atmosphere -

The level of hazardous vapors and background pollutants occurring at the various geographical sites should be estimated by gc-ms computer techniques. Gas chromatography with selective detectors should also be employed for quantitating specific chemical classes of compounds in combination with high resolution columns.

SECTION III

INTRODUCTION

CARCINOGENIC VAPORS IN AMBIENT ATMOSPHERES

Several investigators have postulated the presence of carcinogenic vapors in ambient atmosphere[1-7]. However, until this program was initiated (EPA Contract 68-02-1228) no serious endeavor had been made to sample ambient air to establish their presence and identity. Many hazardous agents are suspected to be introduced directly into the environment via industrial pollution[8]. Potential sources of hazardous vapors such as alkylating agents are ubiquitous. This entity of organic compounds may be associated with textile plants that utilize aziridines and processes such as crease or flame-proofing of textiles, dyeing and printing (e.g. ethylenimine or triethylenemelamine). Alkylating agents are also used in the manufacture of resin products and the finishing of rayon fabrics, and the curing and vulcanizing of rubber (nitrosamines). Carcinogenic and mutagenic vapors are frequently used as intermediates in organic synthesis, e.g. in the preparation of polyvinyl chloride (vinyl chloride), high energy fuel plastics and hydroxyethylated cellulose of fibers (ethylene oxide), surfactants, urethane elastomas, cosmetics (propylene oxide), cellulose acetate (ethylene chlorohydrin), curing of polymers, pharmaceuticals (1,2:3,4 diepoxybutane) and as catalysts for polymerization [diethylsulfate, bis-(chloromethyl)ether]. Organics employed in bulk form for manufacturing such as organic solvents (chloroform, carbon tetrachloride, ethylene oxide, etc.) are also potential sources for high ambient levels of hazardous vapors.

In addition to industrial pollution, photochemical reactions in the atmosphere have been postulated to produce hazardous vapors[9-13]. Because unsaturated hydrocarbons constitute a large fraction of organic air pollutants it is reasonable to assume that carcinogenic and mutagenic products are formed from ozonization, oxidation, substitution or addition reactions (SO_2, NO, NO_2, SO_x, NO_x, etc.) whether spontaneously or photochemically induced. Epoxides, peroxides, aldehydes, ketones, lactones, sulfonates, sultones, and nitro compounds have been in fact isolated in laboratory experiments on olefin oxidation, sulfonation, nitrosation, nitration and ozonization[9].

There is a strong indication nitrosamines are present in the atmosphere; their identification in cigarette smoke has been confirmed[1]. Alkylating compounds resulting from limited-aeration smoldering of plastics, paper and cellulose as well as auto exhaust gases have been demonstrated to occur and have been postulated as a health hazard in industrial areas[2].

In contrast to the above potential sources of pollution, photochemical processes are also important in the production of hazardous vapors. For the Los Angeles area, the photodissociation of nitrogen dioxide into nitric oxide and atomic oxygen is thought to be the most important primary photochemical process[10-13]. Although this may be true for most modern urban areas, it is possible that under different patterns of emission, the dominant role of nitrogen dioxide may be taken over by other primary absorbers. For example, organic compounds which produce hazardous vapors. The free radical reactions are another important feature of atmospheric reactions yielding a variety of products including alkyl nitrates, peroxides, epoxides and hydroperoxides.

On the basis of the current knowledge of air pollution, most of the potentially deleterious vapors which could be formed and/or expelled into the atmosphere could be therefore classified as epoxides, β-lactones, peroxides, hydroperoxides, sulfonates, sultones, nitrosamines, α-chloroalkyl ethers and chlorinated compounds. Some of these pollutants may of course have a very short lifetime in the atmosphere.

PREVIOUS ACCOMPLISHMENTS ON THE DEVELOPMENT OF METHODS FOR CARCINOGENIC VAPOR ANALYSIS IN AMBIENT ATMOSPHERES

During the previous contract period (6/22/73 - 6/21/74) analytical techniques were developed for evaluating collection efficiencies of candidate sorbents during the concentration of hazardous vapors from a flowing stream. The polymeric beads Tenax GC, Porapak Q, Chromosorb 101 and 104 were >90% efficient in trapping hazardous vapors such as epoxides, β-lactones, sulfonates, sultones, n-nitrosamines, chloroalkyl ethers, aldehydes and nitro compounds from synthetic air-vapor mixtures at 0.25 ℓ/min. Tenax GC and Chromosorb 101 were also tested at sampling rates up to 9 ℓ/min and efficiencies of >90% were maintained. Carbowax 400 and 600 and oxypropionitrile coated or chemically bonded to supports and activated carbons were also highly efficient.

A thermal desorption inlet-manifold for recovering and transferring hazardous substances from sorbents to a gas-liquid chromatograph or a gas-liquid chromatograph/mass spectrometer was developed. The interface consisted of a desorption chamber, a six-port two position high temperature/low volume valve, a nickel-capillary trap and a temperature controller. This unit was utilized to determine the temperature rise times in the center of cartridge samplers for a variety of sorbents under isothermal chamber temperatures. The relative heating rates were PCB and BPL activated carbons > oxopropionitrile and Carbowax 400 chemically bonded to Poracil C > Chromosorb 104 > Tenax GC > Chromosorb 101. The heating rates were linear for all sorbents up to 65% of the set desorption chamber (in 60-90 sec) but required several minutes thereafter to reach the final temperature. Since the percent recovery of several hazardous vapors adsorbed on Tenax GC using this inlet-manifold was >90% at the 50 ng level, it was concluded that the designed system was satisfactory for analysis of cartridge samplers.

Design criteria were also developed for a field sampling system for collecting pollutants using a cartridge containing a solid sorbent. The relationship between the ambient vapor concentration, the total volume of air required and the time required for sampling at various flow rates were important considerations in the design specifications. The power required to pump air through sorbent packed tubes was a function of pressure differential (ΔP) across the tube under flow conditions. The ΔP was found to be related to (1) sampling rate, (2) diameter and length of cartridge, (3) particle size distribution and (4) particle shape. Based upon ΔP the power requirements for a pumping system were calculated and applied to the fabrication of a field sampler.

During the previous project period, the methodology and instrumentation developed was also applied to the analysis of air samples from the Los Angeles Basin area. Using glc-ms-comp techniques, many aliphatic and aromatic compounds were identified in these preliminary studies. The relative intensities of single ion plots for ions representing aliphatic and aromatic cracking patterns revealed that Tenax did not efficiently retain background aliphatic constituents (i.e. the breakthrough volume was considerably lower than other compounds), a desirable feature since most hazardous vapors of interest are semi-polar/polar compounds. It was concluded that improved techniques for resolving background pollutants occurring at high concentrations from trace hazardous vapors needed to be developed.

One oxygenated compound of significant interest (in air from West Covina and Santa Monica, CA.) was tentatively identified as styrene oxide.

The perfection of the methodology for collection and analysis of mutagenic and carcinogenic vapors in ambient air was pursued during this project year (6/22/74 - 6/21/75) as well as the application of these techniques for determining the presence of any hazardous vapors in the atmosphere.

SECTION IV
PROGRAM OBJECTIVES

The general scope of this research program was to continue to develop and perfect methodology for reliable and accurate collection and analysis of mutagenic and carcinogenic vapors (collectively termed hazardous compounds) present in trace quantities in the atmosphere down to ng/m^3 amounts. Once the physiologically active vapors present in polluted atmospheres have been determined, researchers can then ascertain which substances need to be routinely analyzed, studied epidemiologically and, eventually, controlled. The major objectives were:

(1) To determine the performance characteristics of a cartridge sampler, specifically the effects of transportation and storage on adsorbents and reliability and accuracy of analysis for collected pollutants, and potential sources of contamination;

(2) To acquire experimental data for optimum performance of adsorbents;

(3) To examine an alternative backup sampling device;

(4) To improve sampling devices and the miniaturization of the system for portability;

(5) To determine and develop techniques for the separation of hazardous substances under study from the many hundreds of organic pollutants which are of secondary interest at this stage;

(6) To determine the identity and relative quantities of background organic pollutants which interfere with major goals of the program;

(7) To undertake a concerted effort to collect field samples at geographical sites postulated to contain hazardous (mutagens, carcinogens, and other alkylating agents) compounds;

(8) To characterize unequivocally the atmospheric pollutants of interest and those hazardous to living organisms using methodology and instrumentation developed under this research program, and

(9) To characterize background atmospheric pollutants which are of secondary interest to this research program.

SECTION V

PERFORMANCE OF SORBENT CARTRIDGE SAMPLER FOR HAZARDOUS VAPORS

Because the concentrations of hazardous vapors sought were anticipated to be in ng/m^3 amounts or less, it was recognized[14] that the major problems would arise with the development of an adequate collection system for concentrating sufficient quantities of material. The relationship between the sampling parameters for collection from ambient air has been previously discussed[14]. To accumulate sufficient quantities of vapors from the atmosphere for qualitative and quantitative analysis, an efficient collection device must be employed[14].

The performance of many sorbents as to their ability to extract and retain hazardous vapors from a moving air stream had not been adequately studied until this program. The parameters which are involved in determining the performance of sorbents can be divided into two categories. There are those on the one hand which are related to sampling environment such as flow rate, air temperature and humidity and those, on the other hand related to the physico-chemical properties of sorbents such as surface area, particle size and porosity, solute capacity, sorption mechanism, degree of solute affinity, etc. Furthermore, some of these factors which influence sorbent performance are not independent of each other. We have previously defined collection efficiency and breakthrough volumes as criteria in order to assess the collection performance of sorbents[14]. Collection efficiency was defined as the fraction of solute vapor in the polluted gas which was retained by the sorbent when a discrete quantity is encountered. On the other hand, when polluted gas enters a sorbent bed, an equilibrium zone is established near the point of entry which, as more pollutant vapor is introduced, may expand through the packing length until the capacity of the sorbent is exceeded. However, if after an initial period of time no additional polluted vapors are introduced and the purging of the packing bed continues, the zones of vapors will move through the packing bed. When the mass zones reach the end of the available packing bed and the vapors begin to leave breakthrough has occurred. Thus, breakthrough volume is simply the elution volume (EV) which can be calculated if the time required for the zone to traverse and elute from the sorbent bed and the sampling rate are known. In an ideal collection system, EV has an infinite value at ambient temperature.

The relationship which describes the amount of vapor adsorbed to a given quantity of adsorbent as a function of pressure, temperature and concentration of the solute vapor is given by the Langmuir equation which has been previously discussed[14].

This section describes further studies on the performance of sorbents for the collection and analysis of hazardous vapors from ambient air utilizing primarily two criteria, collection efficiency and breakthrough volume. Utilizing these two criteria, the performance of Tenax GC is related to environmental factors such as sampling location, temperature and possible interferences from humidity and other gaseous pollutants.

EFFECTS OF HUMIDITY ON COLLECTION EFFICIENCY AND BREAKTHROUGH VOLUME FOR TENAX GC

Different climatic factors are experienced during field sampling which may affect the performance of the Tenax GC cartridge sampler. Because the relative humidity varies considerably between different geographical areas, the ability of Tenax GC to extract hazardous vapors at different humidities was studied. Even though one of the unique features of porous or recrystallized polymers is their low retentive index for water, the collection efficiency or breakthrough volume for some compounds might be altered by the presence of trace amounts of adsorbed water on the surface of the particle. In order that a cartridge sampler may extract vapors from ambient air in a quantitative fashion, it is important that relative humidity does not significantly change adsorption affinity.

We have investigated the effect of water vapor on the quantitative parameters of Tenax GC (collection efficiency and breakthrough volume) for trapping trace amounts of hazardous vapors. The primary objective of this study was to measure the breakthrough volume for a series of hazardous vapors of differing polarities on Tenax GC at defined levels of water vapor in ambient air.

Experimental

The monitoring system described by Pellizzari et al.[15] was used in order to demonstrate the effect of relative humidity on the collection efficiency and breakthrough volume for Tenax GC. This system was modified to incorporate a humidity generator in line with the air flow to the glove box. Because carcinogenic vapors were used in this study, the experiments were executed in a glove box which was evacuated by vacuum through cryogenic safety traps[15]. The desired humidities were generated from a 2 ℓ closed vessel containing 200 ml of water. A refrigeration unit (Type FEN, Haake, Inc., Saddle Brook, NJ) was used to cool the vessel to various calculated temperatures in order to achieve the desired vapor pressures of water (Table 1). Air (breathing quality, Linde Division, Union Carbide, East Brunswick, NJ) from a pressurized reservoir was purified and dehumidifed by passing it through a scrubbing tower (5 cm i.d. x 30 cm in length) which contained layers of calcium chloride dessicant and BPL activated carbon (12 x 30 mesh, Calgon Corp., Pittsburgh, PA) and was delivered first to the humidity generator and then to the glove box arrangement at a rate of 4 ℓ/min. The air stream passed from the humidity generator through the glove box into a 2 ℓ sperical chamber fitted with an injection port where known quantities of hazardous vapors were introduced. The chamber delivered synthetic air-vapor mixtures to the cartridge sampler which contained the sorbent under study[15]. The effluent stream from the sampler was split and a flow of 50-100 ml/min was directed to a flame ionization detector (Model 1200,

Table 1. RELATIONSHIP BETWEEN TEMPERATURE, WATER VAPOR PRESSURE, AND HUMIDITY IN A CLOSED VESSEL CONTAINING WATER

Temperature (°C)	Vapor Pressure (mm Hg)	Absolute Humidity (g/m^3)	Relative Humidity[a] (Percent)
25	23.76	21.6	100
23	21.07	19.8	92
20	17.54	16.2	75
16	13.63	12.9	60
13	11.23	11.3	50
10	9.20	8.8	41

[a] At 25°C.

Varian Instruments Corp., Walnut Creek, CA). Hydrogen and air flow to the flame ionization detectors were 35 and 250 ml/min, respectively. The detector output signal was amplified (Varian Model 520) and recorded with an Omniscribe strip chart recorder (Houston Instruments, Houston, TX). This apparatus monitored total hazardous vapors in the cartridge sampler effluent.

Sorbents were packed in glass tubes (1.056 cm i.d. x 10 cm in length) using 1 cm of silanized glass wool plugs for support. The cartridge samplers were inserted in canisters constructed from "tube L" 3/4 in copper fitted with 3/8 in Swagelock unions. The entrance and exit lines in the monitoring system were 3/8 in o.d. Teflon (Comco Plastics Corp., Raleigh NC).

To synthesize known concentrations of air/solute/vapor mixtures, microliter quantities of each organic compound were injected in to a 2 ℓ sperical flask. The flask was heated to 50° and the air vapor mixture was continuously stirred. An aliquot from this stock reservoir was transferred to the chamber in the monitoring system. By continuously monitoring the cartridge sampler effluent with the flame ionization detector, the collection efficiency of each sorbent was determined. Decay curves which represented the concentration of air/hazardous vapor mixture leaving the chamber per unit time were established for each compound and purging rate by using empty cartridge samplers. The percent collection efficiency was estimated by comparing the areas under curves obtained for samplers with and without sorbent.

Results and Discussion

The relationships between temperature, water vapor pressure and humidity are given in Table 1. At a relative humidity of 50% a cubic meter of air at 25°C contained 11.3 g of water. Thus, when sampling ambient air the cartridge sampler will encounter significant amounts of water during sampling. A large variation in the amount of water present in ambient air is expected when sampling in the various regions throughout the continental United States. For example, in arid regions (Southern California), the relative humidity may be as low as 20%, while in high humidity regions (Gulf Coast), it often exceeds 90%. Therefore, the amount of water vapor can vary as much as four-fold between low and high relative humidity areas. In order to achieve reproducible results it is important that the variation in humidity experienced during sampling does not affect the collection efficiency or breakthrough volume of the sorbent used for extracting hazardous vapors from air.

The effect of humidity on collection efficiency for Tenax GC is depicted in Table 2. The results indicate that for the nine test compounds selected for evaluation, no apparent decrease in the collection efficiency was experienced by increasing the relative humidity from 41-92%. Likewise, the effect of humidity on breakthrough volumes for a number of hazardous vapors was also determined (Table 3). Again in all cases the breakthrough volume did not significantly change when the percent relative humidity was increased from 41-92%. Based upon these experiments, the ability of Tenax GC to collect and retain hazardous vapors in ambient air is relatively unaffected by humidity conditions commonly encountered in field sampling.

These results are consistent with those observations reported by Janák _et al._[17] who studied the effect of water vapor and the quantitative collection of trace components on Tenax GC from headspace of aqueous samples. The specific gas chromatographic retention volume of model compounds (methanol, ethanol, propanol, ethyl acetate, acetone and benzene) on Tenax GC were measured with the use of a carrier gas saturated with water vapor. They found differences between the retention values measured with and without water in the carrier gas to vary approximately ± 10% of the values measured. From this viewpoint, the effect of water can be considered to be insignificant.

EFFECT OF REPEATED THERMAL DESORPTION ON COLLECTION EFFICIENCY OF TENAX GC

One of the outstanding features of Tenax GC is its high operating temperature[14-16,18-24]. At temperatures up to 350° very little background bleeding is observed. Even though this sorbent has a high temperature limit, relatively little is known about the effect of repeated temperature programming on its adsorption affinity for hazardous vapors. Prolonged repeated use of this sorbent at high temperatures might alter its physicochemical properties which in turn could change its collection efficiency and/or breakthrough volume characteristics. In order to further establish the performance characteristics of the Tenax GC cartridge sampler,

Table 2. EFFECT OF HUMIDITY ON PERCENT COLLECTION EFFICIENCY FOR TENAX GC[a]

	Percent Humidity in Ambient Air				
Compound	41	50	60	75	92
Acrolein	100	100	100	100	98
Diethyl sulfate	100	100	100	100	100
Propylene oxide	100	100	100	100	100
Methyl ethyl ketone	100	89	87	100	100
Nitromethane	100	-	-	-	100
Glycidaldehyde	100	-	-	-	100
Bis-(chloromethyl)ether	100	-	-	-	100

[a] All values are in percent and relative to 41% humidity; a sampling rate of 4 ℓ/min was used.

Table 3. EFFECT OF HUMIDITY ON BREAKTHROUGH VOLUMES OF HAZARDOUS VAPORS FOR TENAX GC[a]

	Percent Humidity in Ambient Air				
Compound	41	50	60	75	92
Acrolein	3.2	3.2	3.2	3.2	3.2
Diethyl sulfate	3.0	3.5	3.5	3.5	3.5
Propylene oxide	4.0	4.3	4.0	4.5	4.5
Methyl ethyl ketone	19.5	20.0	20.0	20.0	20.5
Nitromethane	14.0	-	-	-	15.0
Glycidaldehyde	53.0	-	-	-	55.0
Bis-(chloromethylether	172	-	-	-	172

[a] Values are in ℓ/g; a sampling rate of 4 ℓ/min was used.

the effect of repeated thermal desorption on its collection efficiency was examined.

Experimental

Glass cartridges (1.0 cm i.d. x 3.0 in length) containing virgin Tenax GC (35/60) were used. Prior to this study the sorbent was purified by extracting in a soxhlet apparatus with methanol as previously described[1]. A standard mixture of vapor (Table 4) was passed into four identical sampling cartridges. Each loaded cartridge was thermally desorbed and the mixture resolved by gas/liquid chromatography.

Gas-liquid chromatography (glc) was conducted on a Perkin-Elmer 900 series chromatograph (Perkin-Elmer Corp., Norwich, CN) equipped with dual flame ionization detectors. A 2.5 mm i.d. x 3.6 m silanized glass column containing Tenax GC (60/80) sorbent was used for resolving the mixture of hazardous vapors obtained by thermal desorption of loaded cartridges. The column was programmed from 55-250° @ 10°/min with an initial and final isothermal period of 2 and 10 min, respectively. Carrier gas (N_2), hydrogen and air flow were 45, 30 and 250 ml/min, respectively. The injection port, manifold and detector temperature were maintained at 250°.

Peak areas were obtained for each component and an average value was calculated from the four cartridges. Subsequently, two of the four cartridges were emptied and refilled with virgin Tenax GC. The four cartridges were then again loaded with the same standard mixture of vapor and analyzed again by thermal desorption glc. A comparison was made of the average peak area of the two cartridges containing virgin Tenax with the two cartridges which had been previously desorbed. Peak area ratios and the percent recovery were calculated as follows:

$$\text{\% recovery of vapor} = \frac{A_R}{A_V} \times 100$$

where A_R = area of component from sorbent undergoing repeated thermal desorption

A_V = area of component from virgin sorbent

Results and Discussion

The results obtained from repeated thermal desorption of vapors from Tenax GC cartridges are shown in Table 5. These data (and the remaining

Table 4. VOLATILE ORGANIC VAPOR MIXTURE FOR DETERMINING EFFECT OF REPEATED THERMAL DESORPTION ON COLLECTION EFFICIENCY OF TENAX GC[a]

Chemical Family	Compounds
amines	Cyclohexylamine
	Aniline
	N-ethyl aniline
	n-Decylamine
ketones	2-Butanone
	Cyclohexanone
	2,5-Hexanedione
	4'-Fluoroacetophenone
	Propiophenone
ethers	2-Chloroethyl ethyl ether
	Phenyl methyl ether
halogenated substances	Chlorobenzene
	4'-Fluoroacetophenone
	2-Chloroethyl ethyl ether
Nitro compounds	Nitropropane
	Nitrobenzene

[a] An aliquot of vapor containing approximately 100 ng of each component was loaded onto each Tenax GC cartridge.

Table 5. EFFECT OF REPEATED DESORPTION ON PERCENT COLLECTION EFFICIENCY OF TENAX GC CARTRIDGE SAMPLERS[a]

Desorption No.	Compound				
	chlorobenzene	1-nitropropane	phenyl methyl ether	cyclohexyl amine	aniline
1	89	80	87	110	70
2	95	87	93	61	110
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
10	75	79	84	79	73
11	78	80	92	90	84
12	78	74	78	88	86
13	92	93	93	89	95
14	101	97	97	103	97
15	93	86	74	75	82

[a] A 1.0 cm i.d. x 3.0 cm bed of 35/60 mesh Tenax GC was used for the entire study. All desorptions were at 265°. Within each set of desorption steps values were ± 5% for replicate cartridges.

vapors used) indicate that repeated use of Tenax GC does not produce a decrease in the collection efficiency even after recycling the cartridges fifteen times.

A STUDY OF TRANSPORTATION AND STORAGE ON THE PERFORMANCE OF TENAX GC

The use of a cartridge sampler for qualitative and quantitative analysis requires different specifications to ensure the sample which is collected is representative of the ambient air pollutant at a particular site. For the purpose of defining a cartridge sampler in terms of qualitative and quantitative analysis, it is important that the integrity of the hazardous vapors be maintained during collection, transportation and storage of that sample. The purpose of this study was to anticipate and avoid problem areas which might occur during transportation of cartridge samples. The method of packing and transporting the cartridges should prevent contamination of the cartridge or loss of collected vapors during storage.

Experimental

Sets of glass cartridge samplers containing Tenax GC (1.0 cm i.d. x 3.0 cm in length) were used. All cartridges were loaded with approximately 300 ng of each compound (Table 6) using the previously reported monitoring system[14,15]. The experimental design for studying the effect of transportation and storage on Tenax GC cartridges is shown in Table 7. The percent recovery of each hazardous vapor for each set of glass cartridges was compared with that of the cartridges analyzed immediately after loading (reference control). This was accomplished by calculating peak area ratios between the experimental and reference cartridge for each solute.

Gas-liquid chromatography (glc) was conducted on a Perkin-Elmer 900 series chromatograph (Perkin-Elmer Corp., Norwich, CN) equipped with dual flame ionization detectors. A 2.5 mm i.d. x 3.6 m silanized glass column containing Tenax GC (60/80) sorbent was used for resolving the mixture of hazardous vapors thermally desorbed from cartridges. The column was programmed from 35-250° at 10°/min with an initial and final isothermal period of 2 and 10 min, respectively. Carrier gas (N_2), hydrogen, and air flow rates were 45, 30 and 250 ml/min, respectively. The injection port, manifold, and detector temperatures were maintained at 250°.

All cartridge samplers were shipped to Houston, TX and San Francisco, CA by air freight.

Table 6. ORGANIC VAPORS EMPLOYED FOR STUDY ON THE EFFECT OF TRANSPORTATION AND STORAGE ON SAMPLE FROM TENAX GC

Test Vapor	Test Vapor
Glycidaldehyde	Chlorobenzene
β-Propiolactone	1-Nitropropane
Bis-(2-chloroethyl)ether	Cyclohexylamine
Ethyl methanesulfonate	Phenyl methyl ether
Nitromethane	Propane dithiol
Bis-(chloromethyl)ether	Aniline
Butadiene diepoxide	2,5-Hexanedione
N-nitrosodiethylamine	N-Ethyl aniline
Styrene oxide	Nitrobenzene
Cyclohexene oxide	4'-Fluoroacetophenone
1-Bromopropane	Propiophenone
2-Butanone	n-Decylamine
Trichloroethylene	Diphenyl ether
2-Chloroethyl ethyl ether	Sulfolane
Nitroethane	

Table 7. EXPERIMENTAL DESIGN FOR STUDYING THE EFFECT OF TRANSPORTATION AND STORAGE ON TENAX CARTRIDGES

Set No.	Experimental Condition	No. of Cartridges
1	A set of cartridges was analyzed immediately after loading with hazardous vapors (reference controls).	3
2	A set of cartridges was loaded and stored in the laboratory for one week and then analyzed concurrently with Case No. 4.	3
3	A set of cartridges was loaded and stored in the laboratory for 2-4 weeks and then analyzed concurrently with Case No. 5.	3
4	A set of cartridges was prepared, transported and upon return immediately analyzed.	3
5	A set of cartridges was prepared, transported, and then stored in the laboratory 2-4 weeks prior to analysis.	
6	A set of unloaded cartridges was transported and upon return analyzed for possible contamination.	2-3

Results and Discussion

The effects of transportation and storage on the retaining efficiency of Tenax GC for several hazardous vapors are given in Tables 8-11. Cartridge samplers which were either transported or stored for a period of one week gave essentially quantitative recoveries of each of the hazardous vapors examined. A slight decrease in the percent recovery was observed when the cartridges were stored an additional week after transportation (Tables 8-11). Further storage (3-5 weeks) of the cartridge samplers yielded additional decreases in the recovery which can be correlated to the volatility of each of the vapors (Table 8). For example, a recovery of 50% was observed for 1-nitropropane after five weeks of storage.

Quantitative recoveries were obtained in all cases when cartridge samplers were either shipped or stored in the laboratory for a period of up to three weeks. No significant differences were observed between sampling cartridges stored for a period of time with those cartridges which were transported and then stored for the same length of time.

Since all of the vapors were loaded onto cartridges using ambient air which contained <40% relative humidity, the effects of trace quantities of water vapor trapped on the sorbent was not significant. However, experiments which used lab air (relative humidity of approximately 80%) for loading cartridge samplers, we observed a significant decrease in the percent recovery of bis-(chloromethyl)ether (BCME) after a period of a few days. For example, when 50 ng of BCME was loaded onto a Tenax cartridge, only a 50% recovery was obtained the following day. After one week of storage, only trace quantities of bis-(chloromethyl)ether could be detected. This is consistent with the observations of previous investigators[25] who demonstrated that bis-(chloromethyl)ether and mono-(chloromethyl)ether undergo rapid hydrolysis in atmospheres of relatively high humidity. Perhaps an alternative approach to collecting bis-(chloromethyl)ether in ambient air should be investigated, e.g. the collection of the carcinogen as a derivative on the cartridge to stabilize it from further decomposition.

Cartridges (blanks or loaded cartridges) transported in standard cardboard mailing tubes or plastic screw-cap containers developed a high background. In contrast, when cartridge samplers were placed in heavy

Table 8. EFFECT OF TRANSPORTATION AND STORAGE ON THE PERCENT RECOVERY OF VAPORS FROM TENAX GC CARTRIDGES[a]

Compound	Weeks Expired		
	0	3	5
1-Nitropropane	95 ± 2	93 ± 3	50 ± 9
Chlorobenzene	95 ± 2	80 ± 4	50 ± 8
Phenylmethyl ether	95 ± 2	95 ± 2	70 ± 8
N-Ethyl aniline	95 ± 2	95 ± 2	70 ± 6
Nitrobenzene	95 ± 2	95 ± 3	50 ± 9
Aniline	95 ± 2	95 ± 2	80 ± 5
4'-Fluoroacetophenone	95 ± 2	80 ± 4	90 ± 4

[a] Tenax GC cartridge samplers were loaded with vapors and immediately shipped air freight to Houston, TX and returned after two weeks; 0-3 week period includes transport, 3-5 represents additional storage.

Table 9. EFFECTS OF TRANSPORTATION AND STORAGE ON THE PERCENT RECOVERY OF CARCINOGENIC VAPORS FROM TENAX GC[a]

Compound	Weeks Expired			
	Nontransported		Transported	
	0	1	0	1
Glycidaldehyde	95	95 ± 3	95	90 ± 4
β-propiolactone	100	-	100	77 ± 4
Bis-(2-chloroethyl)ether	90	-	90	97 ± 2
Ethyl methanesulfonate	100	-	100	105 ± 3
Nitromethane	-	97 ± 3	-	90 ± 5
Bis-(chloromethyl)ether	100	83 ± 5	100	98 ± 2
Butadiene diepoxide	100	93 ± 4	100	82 ± 4
N-nitrosodiethylamine	100	94 ± 4	100	83 ± 4
Styrene oxide	100	67 ± 8	100	75 ± 10

[a] Tenax GC cartridges were loaded with vapors (900 ng/component), shipped by air freight to San Francisco, CA and immediately returned. Total transportation time was 7 days.

Table 10. EFFECTS OF TRANSPORTATION AND STORAGE ON THE PERCENT RECOVERY OF CARCINOGENIC VAPORS FROM TENAX GC[a]

Compound	Weeks Expired				
	Nontransported		Transported		
	0	1	0	1	2
Glycidaldehyde	95	92 ± 4	95	87 ± 4	50 ± 8
β-propiolactone	100	95 ± 4	100	90 ± 5	85 ± 2
Bis-(2-chloroethyl)ether	90	86 ± 6	90	87 ± 5	>95 ± 2
Ethyl methanesulfonate	100	85 ± 5	100	83 ± 6	>95 ± 2
Nitromethane	-	92 ± 3	-	95 ± 3	85 ± 2
Bis-(chloromethyl)ether	100	65 ± 5	100	58 ± 5	41 ± 4
Butadiene diepoxide	100	76 ± 6	100	75 ± 4	64 ± 5
N-nitrosodiethylamine	100	82 ± 4	100	84 ± 3	62 ± 3
Styrene oxide	100	71 ± 5	100	68 ± 6	70 ± 7

[a] Tenax GC cartridges were loaded with vapors (300 ng/component), shipped by air freight to San Francisco, CA and immediately returned. Total transportation time was 6 days.

Table 11. EFFECTS OF TRANSPORTATION AND STORAGE ON THE PERCENT RECOVERY OF CARCINOGENIC VAPORS FROM TENAX GC[a]

Compound	Weeks Expired				
	Nontransported		Transported		
	0	1	0	1	2
β-Propiolactone	100	100 ± 2	100	95 ± 3	90 ± 2
Bis-(2-chloromethyl)ether	90	100 ± 3	90	100 ± 3	95 ± 3
Ethyl methanesulfonate	100	73 ± 7	100	-	90 ± 3
Nitromethane	100	100 ± 1	100	100 ± 3	85 ± 4
Bis-(chloromethyl)ether	100	100 ± 3	100	90 ± 2	90 ± 3
Butadiene diepoxide	100	100 ± 4	100	91 ± 3	85 ± 2
N-nitrosodiethylamine	100	98 ± 2	100	100 ± 1	96 ± 4
Styrene oxide	100	100 ± 3	100	100 ± 1	88 ± 5
Cyclohexene oxide	100	77 ± 7	100	80 ±	80 ± 4

[a] Tenax GC cartridges were loaded with 300 ng of each compound, shipped by air freight to San Francisco, CA and immediately returned. Total transportation time was 6 days.

duty Corex® glass screw cap (Teflon® lined) centrifuge tubes (50 ml, Corning Glass Works, Corning, New York), the background was negligible. During flight the baggage compartment of an airplane undergoes depressurization (ca. 530 mm Hg) followed by repressurization and this could lead to contamination of the cartridge. Therefore, they should be shipped in containers which are vacuum tight and impermeable to gases. Corex® glass centrifuge tubes satisfied the requirements that a container be durable to avoid damage during shipment and have a vacuum tight seal.

DETERMINATION AND COMPARISON OF BREAKTHROUGH VOLUME AND COLLECTION EFFICIENCY FOR SORBENTS

Because the sorbent Tenax GC exhibits low breakthrough volumes for some of the more volatile hazardous vapors, such as acrolein, propylene oxide, diethyl sulfate, nitromethane and glycidaldehyde, we examined alternate collection media for inclusion as a possible backup material. Several sorbents have been previously reported[14-16,22-24,26-46] as collection media for trapping ambient air pollutants. These sorbents were selected for further testing of collection efficiency for mixtures of hazardous vapors.

Experimental

Collection efficiency and breakthrough volumes were determined by the previously described monitoring system[14]. Glass sampling cartridges packed with Tenax GC (1.0 cm i.d. x 3 cm in length) were used. The flow rate through the cartridge was 4 ℓ/min. Mixtures I and II shown in Table 12 were used to assess collection efficiency and breakthrough volume. Three hundred nanograms of each compound were used.

Tenax GC (35/60), Chromosorb 101 (60/80), Chromosorb 102 (60/80), Chromosorb 104 (60/80), and Porapak-Q (100/200) were purchased from Applied Science, State College, PA. Carbon derived from coke (PCB/BPL, 1230) was acquired from Pittsburgh Activated Carbon Div. of Calgon Corp., Pittsburgh, PA. Cocoanut derived carbons (SAL9190 and 580-26) were purchased from Barneby Cheney, Columbus, OH. Graphtizied carbon (MT) was purchased from Cabot Corp., Boston, MA.

Ethyl methane sulfonate, β-propiolactone, N-nitrosodiethylamine, nitromethane and methyl ethyl ketone were from Fisher Chemicals, Pittsburgh, PA. Glycidaldehyde and cyclohexene oxide were obtained from

Aldrich Chemicals, Milwaukee, WI. From Eastern Organic Chemicals, Rochester, NY, butadiene diepoxide and propylene oxide were purchased. Styrene oxide, bis-(chloromethyl)ether and bis-(2-chloroethyl)ether were from K&K Labs, Plainview, NY.

Table 12. COMPOSITION OF MIXTURES I AND II FOR EVALUATING SORBENT MEDIA

Mixture I	Mixture II
Propylene oxide	Methyl ethyl ketone
Nitromethane	Glycidaldehyde
Bis-(chloromethyl)ether	β-Propiolactone
Butadiene diepoxide	Cyclohexene oxide
N-Nitrosodiethylamine	Bis-(2-chloroethyl)ether
Styrene oxide	Ethyl methanesulfonate

Results and Discussion

The collection efficiencies and breakthrough volumes for several sorbents are shown in Table 13. Contrary to the results obtained by Ramond and Guiochon[28], we found that graphitized carbon was inferior as a sorbent for collecting volatile hazardous vapors. The collection efficiency for Mixture I and II was only 27% and 20%, respectively. In a separate experiment, the collection efficiency of graphitized carbon was determined for each compound listed in Table 13. The collection efficiency for nitromethane and butadiene diepoxide was only 50%. The remaining compounds in Mixture I exhibited 0% collection efficiency. In contrast, the collection efficiencies for the remaining carbons, Tenax GC, Porapak-Q and the Chromosorbs were all 100% (Table 13).

The breakthrough volumes for propylene oxide and methyl ethyl ketone were determined for these sorbents since they were the most volatile compounds in the series studied. As shown in Table 13, higher breakthrough volumes were experienced with the carbon sorbents than with Tenax GC, Porapak-Q, Chromosorb 101 and 102. On the other hand, breakthrough had not occurred on Chromosorb 104 even after 36 ℓ of air had been purged

Table 13. COMPARISON OF COLLECTION EFFICIENCIES AND BREAKTHROUGH VOLUMES FOR SEVERAL SORBENTS

Sorbent	Collection Efficiency (%)		Breakthrough Volume (ℓ)	
	I	II	Propylene oxide	MEK
Graphitized carbon	27	20	-	-
PBL Carbon	100	100	36	20
PCB Carbon	100	100	40	16
SAL9190	100	100	40	28
M1808	100	100	24	12
Tenax (35/60)	100	100	4	6
Porapak Q (100/120)	100	100	4	6
Chromosorb 101 (60/80)	100	100	4	10
Chromosorb 102 (60/80)	100	100	8	>28
Chromosorb 104 (60/80)	100	100	>36	>36

through the cartridge sampler. On the basis of these experiments it was concluded that the candidate sorbents which may serve as backup material to Tenax GC are Chromosorb 104, BPL and PCB carbons and SAL19190 and M1808 cocoanut carbons.

ESTIMATION OF BREAKTHROUGH VOLUMES FOR SEVERAL HAZARDOUS VAPORS ON TENAX GC AND CHROMOSORB 104

Estimation of breakthrough volumes, i.e. the volume of air sampled which is required to move the mass transfer zone to the end of the available packing bed, provides a further assessment of the performance of sorbents as to their utility for quantitative collection of hazardous vapors from ambient atmosphere. This section describes and compares three methods for the determination of breakthrough volumes for several highly volatile carcinogenic compounds on Tenax GC and Chromosorb 104. A comparison was made between values obtained under laboratory and field conditions. The possible effects of displacement chromatography by background pollutants and premature breakthrough was determined.

Experimental

Estimation of breakthrough volumes was determined using three completely independent methods. The first method (No. 1) consisted of determining the elution volume for an organic vapor on a gas chromatographic column packed with the sorbent Tenax GC. A column with the dimensions of 2.5 mm i.d. x 3.6 m in length was used. Each hazardous vapor (approximately 900 ng) was injected onto this column and the elution volume was determined as the product of flow rate and elution time. After injecting vapors under a series of increasing temperatures, a plot was made as the log of the reciprocal of the elution volume vs temperature (Fig. 1). Using a linear regression analysis, the breakthrough volume (50% loss) for ambient conditions was determined by extrapolating to 25°C. At the end of the experiment, the Tenax sorbent in the chromatographic column was removed and weighed. The breakthrough volume was expressed in terms of ℓ/g of sorbent.

The second method (No. 2) for determining breakthrough volume was to observe the disappearance of hazardous vapors from a Tenax GC cartridge sampler. Sampling cartridges containing sorbent (1.5 cm x 6.0 cm in length) were loaded with hazardous vapors and then purged with known

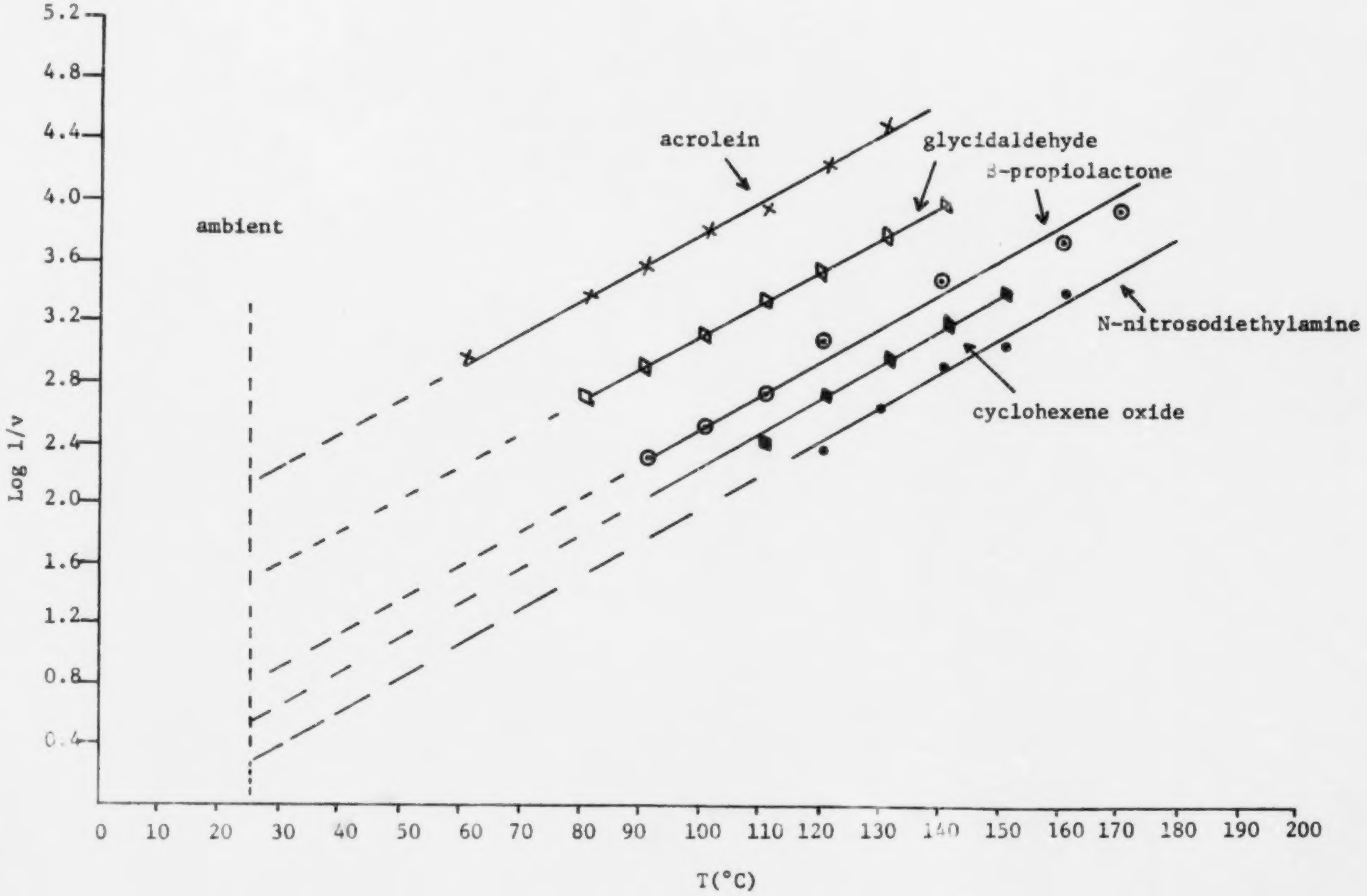


Figure 1. Linear regression of the elution volume vs temperature for vapors on Tenax GC.

volumes of air at a rate of 4 ℓ/min. A calibrated volume of air was passed through the cartridge, after which it was thermally desorbed and analyzed by glc.

Gas-liquid chromatography (glc) was conducted on a Perkin-Elmer 900 series chromatograph (Perkin-Elmer Corp., Norwich, CN) equipped with dual flame ionization detectors. A 2.5 mm i.d. x 3.6 m silanized glass column containing 2% DEGS on Supelcoport (80/100 M) was used for resolving the mixture of hazardous vapors obtained by thermal desorption of cartridge samplers. The column was programmed from 55-200° @ 10°/min with an initial and final isothermal period of 2 and 10 min, respectively. Carrier gas (N_2), hydrogen and air flow were 45, 30 and 250 ml/min, respectively. The injection port, manifold and detector temperatures were maintained at 250°.

By comparing cartridges which were loaded with known quantities (100 ng) of hazardous vapors with cartridges which had been purged with known volumes of air, the amount of each carcinogen which had disappeared was determined. That volume of air which decreased the concentration of carcinogen by 50% constituted the breakthrough volume.

Another technique (No. 3) for measuring breakthrough volumes for hazardous vapors under laboratory conditions employed a monitoring system described elsewhere[14].

To determine the elution volume of vapors under field sampling conditions, a dual tandem cartridge arrangement (No. 4) was used. The Universal Sampler 51068 (Research Appliance Co., Allison, PA) was used. The sampler and multiple-port chamber which accommodated the use of several cartridges simultaneously during a sampling period have been previously described[14]. At the beginning of each sampling period a known quantity of vapor (phenyl methyl ether, nitrobenzene, acrolein, trichloroethylene, 2-chloroethyl ethyl ether, bis-(chloromethyl)ether and chlorobenzene, approximately 150 ng each) was loaded onto cartridge samplers. Periodically the back cartridge in the tandem arrangement was replaced with a vargin one and sampling was continued for a brief period (1-5 min, with up to 40 ℓ passing through it) and then the backup cartridge was examined by thermal desorption gas-liquid chromatography. Peak areas for each standard vapor were calculated to determine the amount of vapor disappearing from the front cartridge and appearing in the backup cartridge. At the maximum response observed by flame ionization detection, the elution volume was calculated from the elution time and sampling rates. Breakthrough occurred when 50% of the vapor had passed through the front cartridge.

Results and Discussion

A comparison of the breakthrough volumes obtained by Methods No. 1 and 2 for a series of vapors on Tenax GC is given in Table 14. All the breakthrough volumes obtained for each of the hazardous vapors were in good agreement between the two methods employed. Of the compounds tested, the lowest breakthrough volume (approximately 7-9 ℓ/g of Tenax GC) was exhibited by propylene oxide. Since a typical glass sampling cartridge contained 2.2 g of Tenax sorbent (1.5 cm i.d. x 6.0 cm in length) the breakthrough volume is approximately 16 ℓ. Because the determination of breakthrough volumes utilizing method No. 1 was in good agreement with the second method which is more laborious, the first method was used for determining the breakthrough volume of several additional hazardous vapors. These results are shown in Table 15. These results clearly indicate that the elution volume for a compound on Tenax GC sorbent is highly dependent

Table 14. COMPARISON OF BREAKTHROUGH VOLUMES
OBTAINED FROM TWO DIFFERENT TECHNIQUES
FOR TENAX GC[a]

	Breakthrough Volume ℓ/g	
Test Compound	Method No. 1	Method No. 2
Propylene oxide	7	9
Nitromethane	40	42
Glycidaldehyde	70	51
β-Propiolactone	158	130
Bis-(chloromethyl)ether	189	186
Butadiene diepoxide	306	270

[a] See text for description of two methods employed; each value is an average of duplicate determinations.

Table 15. BREAKTHROUGH VOLUMES FOR SEVERAL HIGHLY VOLATILE COMPOUNDS ON TENAX GC (35/60 MESH) CARTRIDGES

Compound	Breakthrough Volume (ℓ)[a]	
	2.15 g Tenax (1.5 cm i.d. x 6.0 cm)	2.87 g Tenax (1.5 cm i.d. x 8.0 cm)
Acrolein	9.7	13.0
Propylene oxide	15.0	20.0
Diethyl sulfate	19.1	25.4
Nitromethane	23.8	31.7
Glycidaldehyde	147.0	195.0
β-propiolactone	333.0	440.0
Bis-(chloromethyl)ether	400.0	530.0
Butadiene diepoxide	646.0	860.0
Cyclohexene oxide	1,040.0	1,380.0
Diethylnitrosamine	1,220.0	1,620.0
Aniline	2,100.0	2,800.0
Ethyl methanesulfonate	2,420.0	3,220.0
Styrene oxide	7,550.0	10,000.0
Acetophenone	2,880.0	3,830.0

[a] Volume required to elute one-half of adsorbed vapor at 25°C.

upon the molecular structure. The elution volume for acrolein on a standard glass sampling cartridge (1.5 cm i.d. x 6 cm in length) was 9.7 ℓ. By increasing the cartridge length from 6 to 8 cm, the elution volume is increased from 9.7 to 13.0 ℓ (for acrolein) which is predicted from the 1.34 ratio of bed depths. The increase in the breakthrough volume is also apparent in the case of styrene oxide which for a 6 cm length cartridge was 7.5 m^3 whereas on an 8 cm cartridge the elution volume increased to 10 m^3.

The breakthrough volumes were also determined for Chromosorb 104 using method No. 1 (analysis on a gas chromatographic column). Extrapolation of the linear regression analysis to 25° yielded the breakthrough volumes shown in Table 16. Table 17 compares the breakthrough volumes for Tenax GC and Chromosorb 104. On Chromosorb 104, the breakthrough volume for propylene oxide was four times greater than on Tenax GC. For nitromethane, it was nine times larger. These data indicate that Chromosorb 104 indeed has a much higher retentive volume for the volatile hazardous compounds employed in this study. Thus it may serve as a backup sorbent material for trapping the more volatile hazardous vapors which may pass through the Tenax GC sorbent bed; however, the retention index for water on Chromosorb 104 is larger and preliminary observations indicate that the quantity of water vapor retained is an order of magnitude greater. Further investiations are warranted on the performance of Chromosorb 104 and the carbons as potential alternate collecting media for hazardous vapors.

Since all of the results thus far were obtained under laboratory conditions which do not include the background pollution profile normally encountered under field sampling conditions, these results represent the maximum expected breakthrough volume. Under field sampling conditions, it is conceivable that the elution volume may decrease _via_ displacement chromatography by other pollutants. Breakthrough volumes under field sampling conditions were also determined in order to compare these values to those obtained under ideal or laboratory conditions.

We had previously reported studies on the breakthrough volume under field sampling conditions[14]. These studies had indicated that premature breakthrough had not occurred under field sampling conditions in locations

Table 16. BREAKTHROUGH VOLUMES FOR CHROMOSORB 104[a]

Test Compound	ℓ/g
Nitromethane	246
Diethyl Sulfate	113
Acrolein	40
Propylene Oxide	32

[a] Determined by Method No. 1, see text for explanation.

Table 17. COMPARISON OF BREAKTHROUGH VOLUMES
FOR TENAX GC AND CHROMOSORB 104

Test Compound	Tenax GC[a]	Chromosorb 104
Propylene oxide	8	32
Nitromethane	27	246

[a] Average of two techniques.

where the magnitude of the pollution profile was small (Table 18)[14]. Further breakthrough studies were executed in an area which was regarded as having a high pollution background (Beltline-U.S. 1 and Western Blvd., Raleigh, NC). The breakthrough for five hazardous vapors is given in Table 19. For a cartridge with the dimensions of 1.5 cm i.d. x 3 cm in length, the breakthrough volumes for acrolein, trichloroethylene, 2-chloroethyl ether, bis-(chloromethyl)ether and chlorobenzene were 5, 52, 112, 302 and 352 ℓ, respectively (Table 19). Calculation of the breakthrough volume on a ℓ/g basis is shown in Table 20. Also given is the breakthrough volume for a standard glass sampling cartridge of 1.5 cm i.d. x 6.0 cm in length. Comparison of the breakthrough volumes obtained under laboratory conditions (Table 15) and under field sampling conditions (Table 20) for acrolein and bis-(chloromethyl)ether indicates that field sampling for these two constituents under a heavy pollution profile did not induce premature breakthrough. We are currently determining the breakthrough volume for trichloroethylene, 2-chloroethyl ethyl ether and chlorobenzene using method no. 1 under laboratory conditions in order to compare these values with those obtained under field sampling conditions. In general, massive premature breakthrough does not seem to occur when sampling is performed under a high pollution profile which is primarily auto exhaust.

Table 18. BREAKTHROUGH STUDY OF ORGANIC VAPORS DURING FIELD SAMPLING[a]

Sampling Time (min)	Volume Air Sampled (ℓ)	Peak Areas (cm^2)		
		Phenyl methyl ether	Toluene	Nitrobenzene[b]
30	350	0	0	0
60	710	0	0	0
90	1060	0	0	0
150	1770	0	4.5	0
210	2480	0	5.4	0
270	3190	0	5.5	0
300	3540	0	0	0
330	3890	0	0	0
360	4250	0	0	0
390	4600	0	0	0
420	4960	0	0	0
480	5660	0	0	0
540	6370	0	0	0
570	6730	0	0	0
600	7080	0	0	0
660	7790	0	0	0
720	8500	0	0	0
750	8850	10.8	0	0
810	9560	3.0	0	0
870	10270	0	0	0
930	10970	0	0	0
960	11330	0	0	0

[a] Tenax GC (35/60) cartridge (1.5 cm i.d. x 6 cm in length); sampling was 24 ℓ/min. Sampling was in the Research Triangle Park, N. C.

[b] Breakthrough volume was >12 m^3.

Table 19. BREAKTHROUGH STUDY OF HAZARDOUS VAPORS DURING FIELD SAMPLING[a]

Sampling Time (min)	Volume Air Sampled (ℓ)	Peak Area (cm^2)				
		Acrolein	Trichloro-ethylene	2-Chloroethyl-ethyl ether	Bis-(chloromethyl)-ether	Chlorobenzene
0.3	3	15.0	0	0	0	0
0.5	5	16.6[b]	0	0	0	0
0.6	7	13.2	0	0	0	0
1.2	12	0	0	0	0	0
1.7	17	0	0	0	0	0
2.2	22	0	0	0	0	0
5.2	52	0	9.8[b]	5.8	0	0
8.2	82	0	6.5	7.2	0	0
11.2	112	0	3.1	9.5[b]	0	0
16.2	162	0	1.9	9.0	0	0
18.2	182	0	0	8.0	0	2.5
20.2	202	0	0	2.5	3.0	2.6
22.2	222	0	0	0	5.2	3.1
30.2	302	0	0	0	14.2[b]	6.2
35.2	352	0	0	0	12.4	7.3[b]
40.2	402	0	0	0	5.8	6.0

[a] Tenax GC (35/60) cartridge (1.5 cm i.d. x 3 cm in length). Field sampling was at Beltline-U.S. 1 and Western Boulevard, Raleigh, NC. Vapors were resolved on a 200 ft OV-101 SCOT programmed from 30-220° @ 4°/min.

[b] Represents 50% breakthrough point.

Table 20. BREAKTHROUGH VOLUME OF HAZARDOUS VAPORS FOR TENAX GC (35/60) OBTAINED DURING FIELD SAMPLING

Compound	Breakthrough Volume	
	ℓ/g	1.5 cm i.d. x 6.0 cm cartridge
Acrolein	2.8	10
Trichloroethylene	51.6	104
2-Chloroethyl ethyl ether	104.2	224
Bis-(chloromethyl)ether	280.9	604
Chlorobenzene	325.6	700

SECTION VI

DESIGN AND PERFORMANCE OF A PORTABLE FIELD SAMPLER

Collection of pollutants by other investigators has been performed at modest flow rates (20-2000 ml/min), because the concentrations of these substances were relatively high (ppm). In contrast, the sampling rates and time required for this research program were larger, since the hazardous vapors were anticipated to occur at the low ng/m^3 levels (ppb)[14]. This relationship between sampling rate, sampling time and the concentration of pollutants in ambient air was previously discussed[14].

In order to collect sufficient quantities of each atmospheric carcinogen for qualitative and/or quantitative analysis, the field sampling unit had to meet several requirements. These were: (1) a sampling rate adjustable from 0-3 m^3/hr at the pressure drop generated with a sampler cartridge in-line, (2) a capability of multiple cartridges on-line during a sampling period, (3) uninterrupted 24 hr operation, and (4) the option to push or pull air samples through the cartridge sampler. All of these factors ultimately determined the power (milliamps/ℓ/min) required for sampler operation.

Also, these and additional factors were found not to be independent of each other[14]. Other limitations were found to be imposed by: (1) the collection efficiences of the packing, (2) sorbent breakthrough characteristics, (3) the lowest detectable concentrations of the carcinogenic compounds by the instrumental technique, and (4) the size and shape of the cartridge sampler and how pressure differential increases with increased flow through it. Because contamination of a sample was to be avoided, the pump design was also an important characteristic. Of these criteria considered in designing a field sampling unit, the pressure differential developed across a cartridge at a specified flow rate was deemed the most important criterion and was treated in some detail in the previous report[14].

The power required to pump air through sorbent-packed tubes is a function of pressure differential (ΔP) across the tube under flow conditions. The ΔP is related to: (1) sampling rate, (2) diameter and length of cartridge, (3) particle size distribution, and (4) particle shape. A mathematical expression was derived for calculating ΔP using the physico-chemical properties of the sorbent[14]. Based upon ΔP, the power requirements for a pumping system were calculated and applied to the fabrication of a portable field sampler.

In this section the power requirements, the fabrication of a portable sampler, and the testing of portable field samplers is described.

POWER REQUIREMENT

From the value of ΔP, the theoretical power (watts) required for compression or expansion of the air and its delivery through the sampler was estimated using a formula derived from the Moss and Smith equation for adiabatic horsepower[47]. The formula employed was:

$$\text{Power (Watts)} = \ell/\text{min} \times 5.968 \times [(p_1/p_2)^{\frac{k-1}{k}} - 1]$$

where p_1 and p_2 are the high and low pressures across the sampler, respectively and k is a ratio of specific heats for air, C_p and C_v. This formula is based upon air at 14.7 psi, 23°C and 36% relative humidity. Its density was taken at 0.075 lb/ft^3, k was set at 1.3947.

Figure 2 depicts the theoretical power required to pump air through a 5 cm depth of sorbent packing. For a flow rate of 20 ℓ/min, the change from 60/80 mesh particles to 18/20 in the 1.06 cm tube, reduces power requirements by a factor almost of 5 (30.4 watts to 6.4). Increasing the tube diameter from 1.06 cm to 1.82 cm decreases power for the 60/80 mesh packing from 30.4 to 21 watts. It was concluded that tube diameters of approximately 1.5 cm, particles of about 35/60 mesh and bed depths of about 5 cm would allow sampling rates of 20 ℓ/min for a theoretical power consumption of 15 watts (0.02 horsepower). However, practical power requirements are expected to be at least twice the theoretical values to allow for power losses in the pump itself. For example, a cartridge of Tenax GC 35/60 mesh in a 1.82 cm tube would require twice the theoretical 7.4 watts or 14.8 watts to sample air at 20 ℓ/min. It is apparent that most of the sampling for qualitative analysis would therefore require the use of storage batteries which have the necessary capacity.

FABRICATION OF PORTABLE SAMPLERS

In conjunction with Dr. Lou Ballard of Nutech Corp., (Durham, NC), two portable field samplers were custom-built according to the criteria

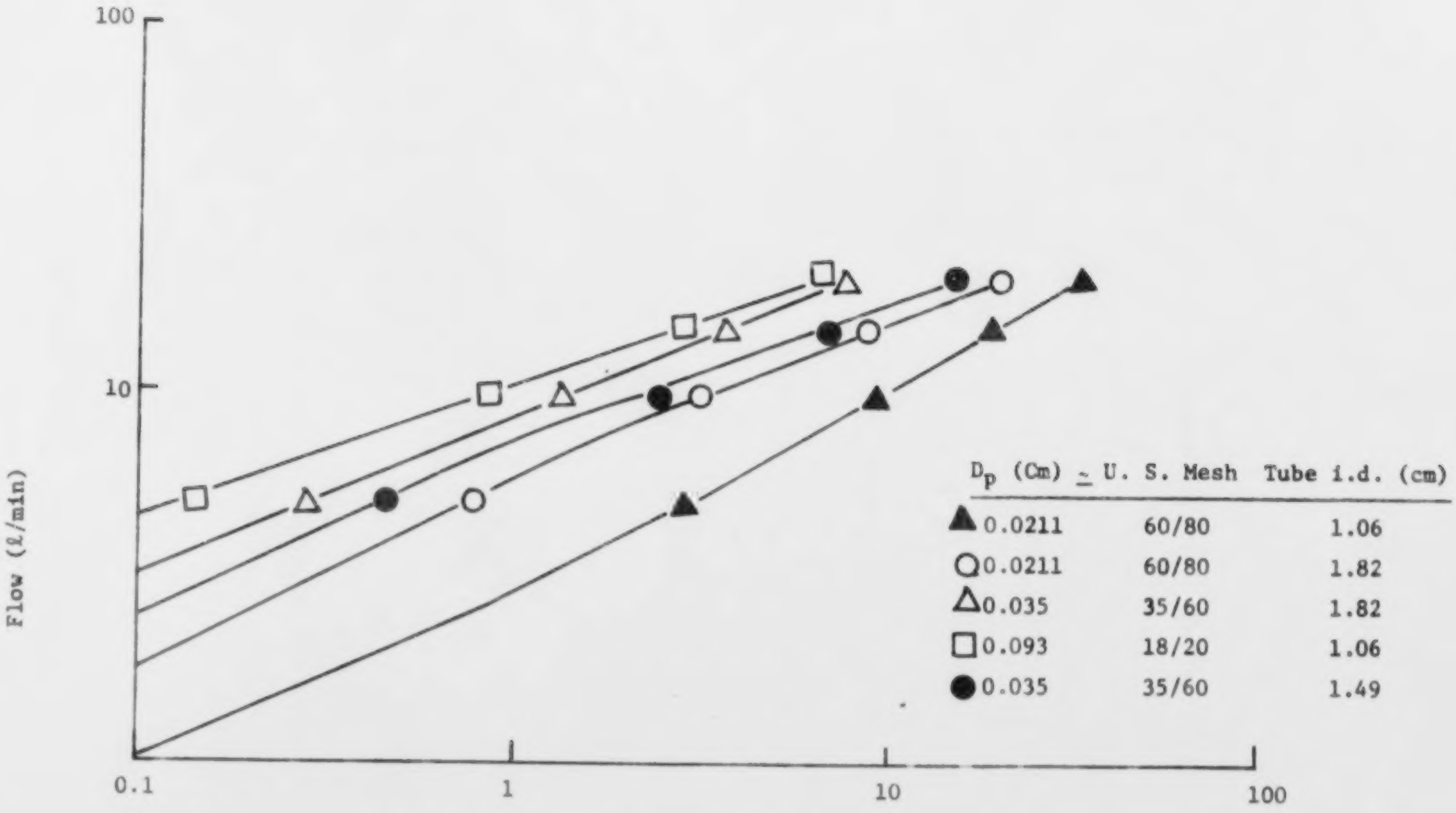


Figure 2. Relationship between flow rate and theoretical power requirements at various tube diameters and particle size.

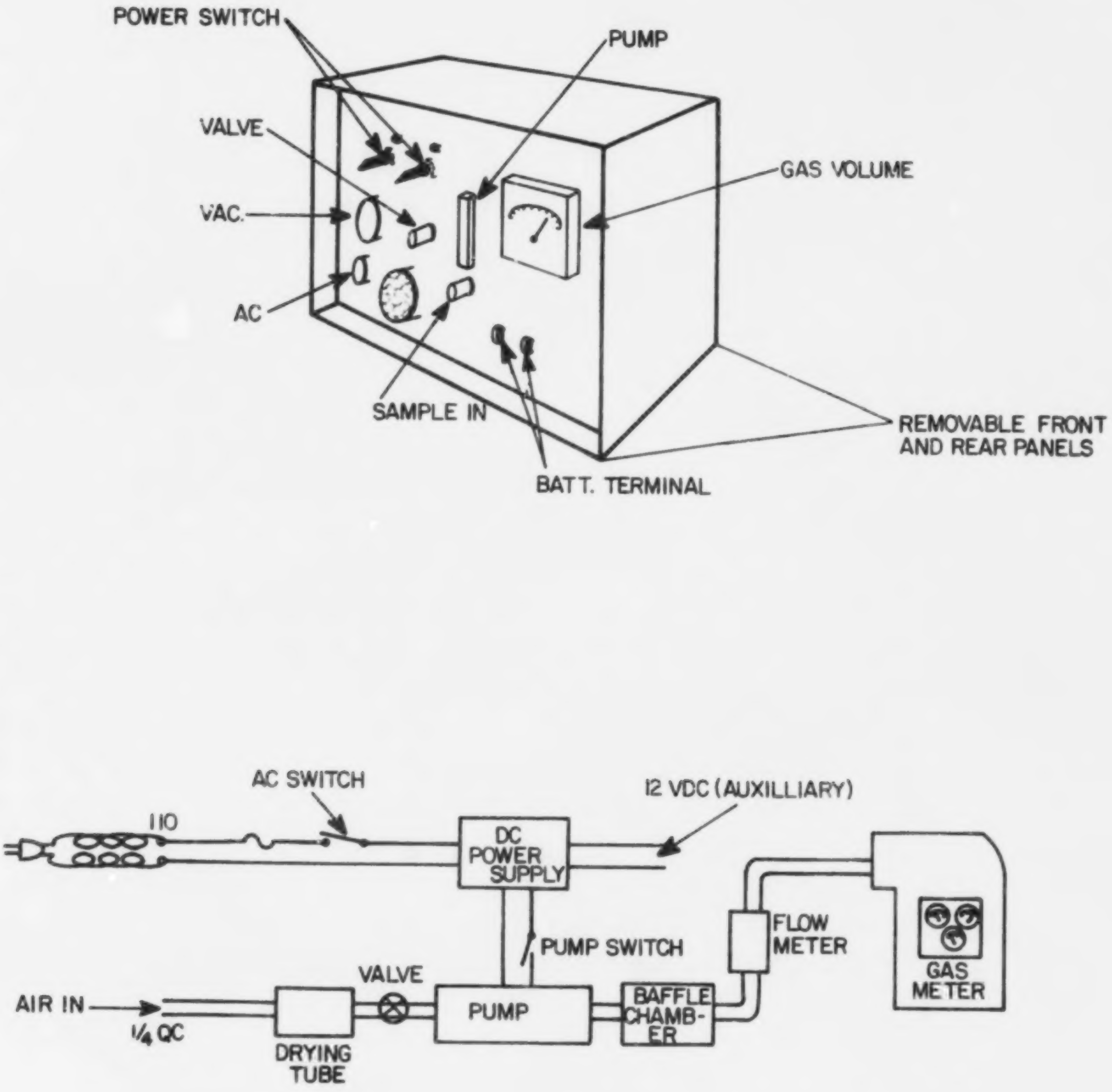
outlined under the power requirements as well as additional general requirements. These were: (a) an AC/DC converter for 115 V AC/12 V DC operation, (b) capability of flow rates up to 15 ℓ/min, (c) capable of pulling 7-8 ℓ/min at a pressure of 5 in of mercury, (d) a power requirement of 15 watts at 5 in of mercury pressure drop, (e) capable of operating for 8 hr on a 12 V storage battery (50 amp-hr), (f) a gas meter for registering a total of up to 10,000 ft^3, (g) a flow meter for regulating flow rates of 0-10 ℓ/min under sampling conditions, (h) a quarter inch quick connect to the vacuum line for attaching cartridge samplers, and (i) a vacuum gauge and a diaphragm pump with a dampening chamber.

The portable samplers which were fabricated according to these design criteria are shown in Figure 3. The present design allowed AC/DC operation and while in the AC mode, the DC power supply was used to recharge 12 V storage batteries while simultaneously operating the diaphragm pump as a field sampler. The AC/DC (Model No. 221A) sampler consisted of a pump, flow meter, gas meter, and quick connect fittings and is depicted in Figure 3. Air was drawn through the cartridge samplers which were attached to a quarter-inch connect fitting. A drying tube packed with Drierite® was interposed between the cartridge samplers, in order to remove excess amounts of moisture and protect the diaphragm pump. A Whitey valve (Whitey, Co., Oakland, CA) is used for regulating the sampling rate. A vacuum gauge which is not shown in the figure can be located between the cartridge sampler and the regulating valve. A baffle chamber is interposed between the pump and flow meter in order to provide non-pulsed flow through the flow and gas meters so that more accurate gas flow measurements may be obtained.

The portable field samplers weighed approximately 23 lb. The carrying case was 39 cm x 37 cm x 27 cm (w x h x d). Located on the front panel were the AC/DC and pump power switches, the gas volume meter, vacuum gauge, flow regulating valve, and an amp meter and a flow meter.

EXAMINATION OF PORTABLE SAMPLER PERFORMANCE

The two portable Nutech Model 221A samplers were examined under field sampling conditions. The relationship between flow rate, pressure differential, and cartridge dimensions for the samplers operated in the AC mode are depicted in Table 21. Two cartridge dimensions (1.0 and 1.5 cm i.d.) and two particle sizes of Tenax GC were examined at various flow rates



POWER SWITCH
PUMP
VALVE
GAS VOLUME
VAC.
AC
SAMPLE IN
REMOVABLE FRONT AND REAR PANELS
BATT. TERMINAL
AC SWITCH
12 VDC (AUXILLIARY)
110
DC POWER SUPPLY
FLOW METER
PUMP SWITCH
GAS METER
VALVE
AIR IN
1/4 QC
PUMP
BAFFLE CHAMBER
DRYING TUBE

Figure 3. Nutech Model 221-A AC-DC Sampler

Table 21. RELATIONSHIP BETWEEN FLOW RATE, PRESSURE DIFFERENTIAL, AND CARTRIDGE DIMENSIONS FOR NUTECH MODEL 221-A PORTABLE SAMPLERS (AC MODE)

Cartridge Size (cm i.d. x cm in length)	No.	Mesh	F, ℓ/min (ΔP, in Hg)	
			Sampler No. 1	Sampler No. 2
1 x 6	1	60/80	2 (4)	2 (4)
			4 (9.5)	4 (9.7)
			4.5 (11.5)	4.7 (12)
	2	60/80	2 (1)	2 (1.5)
			4 (2.7)	4 (3.7)
			7 (7)	7 (8)
1.5 x 6	1	60/80	2 (1.6)	2 (2.2)
			4 (4.7)	4 (5.5)
			6.2 (8.5)	6 (9.5)
	2	60/80	2 (0.2)	2 (0.8)
			4 (1.6)	4 (1.8)
			8 (5.2)	8.2 (5.6)
1 x 6	1	35/60	2 (2)	2 (2.5)
			4 (5.8)	4 (6.8)
			5.5 (9.5)	5.5 (10.5)
	2	35/60	2 (0.1)	2 (0.6)
			4 (1.5)	4 (1.8)
			7.7 (5.5)	8 (6.0)
1.5 x 6	1	35/60	2 (1)	2 (1.5)
			4 (3)	4 (3.5)
			6.7 (7.2)	6.7 (8.5)
	2	35/60	2 (0.1)	2 (1.0)
			4 (0.7)	4 (3.6)
			8.7 (3)	9 (4.5)

on samplers 1 and 2. For a single cartridge of 1.0 cm i.d. the maximum flow rate obtainable was approximately 4.6 ℓ/min at a pressure drop of 11.8 inches of mercury. This condition represented the lowest flow rate and highest pressure drop experienced. In contrast a cartridge of 1.5 cm i.d. containing 35/60 mesh sorbent allowed a flow rate of 6.7 ℓ/min to be achieved. These performance data using the portable samplers in the AC mode are well within the design specifications.

The relationships between flow rate, pressure differential, and cartridge dimensions for these portable samplers were also examined in the DC mode. These results are shown in Table 22. The relationships between flow rate and pressure differential were similar to those observed when the samplers were operated in the AC mode. However, in this case, we measured the amperage required to operate the samplers under various flow rates. In general the requirement was 2.0-2.5 amps, depending on the cartridge size, sorbent mesh, and flow rates employed. On the basis of the amperage values obtained from this experiment, it can be concluded that for a standard 12-volt 50 ampere-hour storage battery, the maximum sampling period attainable is approximately 20 hours.

The performance of the portable samplers under battery operation was also examined over a typical sampling period. These results are shown in Table 23. The sampling rate, pressure differential, and current drawn were relatively constant for a 9-hour sampling period. At the end of the sampling period the remaining battery charge was approximately 50%.

Based on the results obtained for the two samplers as shown in Tables 21-23, the performance of the portable field samplers was within the design specifications described above.

Table 22. RELATIONSHIP BETWEEN FLOW RATE, PRESSURE DIFFERENTIAL, AND CARTRIDGE DIMENSIONS FOR NUTECH MODEL 221-A PORTABLE SAMPLERS (DC MODE)[a]

Cartridge Size (cm i.d. x 3 m in length)	No.	Mesh	Sampler # 1		Sampler # 2	
			F, ℓ/min (ΔP)[a]	Amp	F, ℓ/min (ΔP)	Amp
1 x 6	1	60/80	2 (3.5)	2.0	2 (4.8)	1.9
			4 (9.0)	2.1	4 (9.8)	2.0
			4.7 (11.5)	2.2	4.5 (12)	2.1
	2	60/80	2 (0.7)	2.0	2 (1.5)	1.8
			4 (2.3)	2.1	4 (3.7)	2.0
			7 (7.2)	2.4	7 (8)	2.2
1.5 x 6	1	60/80	2 (1.1)	2.0	2 (1.4)	1.8
			4 (3.0)	2.1	4 (3.7)	1.9
			7 (7.5)	2.3	7 (8.5)	2.2
	2	60/80	2 (0.1)	2.0	2 (0.5)	1.9
			4 (3.0)	2.1	4 (1.5)	2.0
			8.0 (3.7)	2.4	8 (4.5)	2.2
1 x 6	1	35/60	2 (2.2)	2.0	2 (2.5)	1.9
			4 (5.2)	2.2	4 (6.1)	2.0
			5.7 (9.5)	2.3	5.5 (10.2)	2.1
	2	35/60	2 (0.1)	2.0	2 (0.4)	2.0
			4 (2.0)	2.1	4 (2.2)	2.1
			8 (5.7)	2.4	8 (6.3)	2.4
1.5 x 6	1	35/60	2 (0.9)	2.0	2 (1.2)	1.8
			4 (3.2)	2.1	4 (3.7)	2.0
			7 (7.8)	2.3	7 (8.2)	2.1
	2	35/60	2 (0.1)	2.0	2 (0.1)	1.8
			4 (0.4)	2.1	4 (1.1)	2.0
			9 (3.6)	2.5	9 (4.2)	2.3

[a] A 12 V, 50 amp-hr storage battery was used; ΔP is in in. Hg.

Table 23. PERFORMANCE OF NUTECH MODEL 221-A PORTABLE FIELD SAMPLERS UNDER BATTERY OPERATION[a]

Time Elapsed (hr)	Sampler No. 1				Sampler No. 2			
	Flow (ℓ/min)	Vacuum (in Hg)	Volume (ℓ)	Amp	Flow (ℓ/min)	Vacuum (in Hg)	Volume (ℓ)	Amp
1	9.0	3.3	511	2.3	9.2	3.7	500	2.5
2	9.0	3.2	980	2.2	9.2	3.7	1,100	2.2
3	9.2	3.2	1,480	2.2	9.2	3.7	1,650	2.2
4	9.2	3.2	1,940	2.2	9.2	3.7	2,200	2.2
5	9.5	3.2	2,300	2.2	9.5	3.7	2,600	2.1
6	9.5	3.2	2,940	2.2	9.5	3.7	3,120	2.1
7	9.5	3.2	3,420	2.2	9.5	3.7	3,580	2.1
8	9.5	3.2	3,930	2.1	9.5	3.7	4,040	2.1
9	9.5	3.2	4,330	2.1	9.6	3.7	4,500	2.0
9.6	9.5	3.2	4,600	2.1	9.6	3.7	4,960	2.0

[a] Two Tenax GC cartridges (1.5 cm i.d. x 6.0 cm in length) were employed; 12V, 50 amp-hr storage battery was used.

SECTION VII

IDENTIFICATION OF HAZARDOUS AND BACKGROUND POLLUTANTS FROM SEVERAL GEOGRAPHICAL AREAS IN THE CONTINENTAL U.S.

Several sites within three geographical areas (Figures 4-6) were selected for collection and analysis of hazardous and background ambient air pollutants. The rationale for site selection was based upon the presence of either a highly industrialized area and/or the presence of photochemical smog. The three areas selected were: the Kanawha Valley in West VA, greater Houston, TX area, and Los Angeles, CA Basin.

Located in the Kanawha Valley are many manufacturers of organic and inorganic chemicals. DuPont (near Belle, West VA) has a large ammonia organic chemical complex for the synthesis of substances such as substituted dianilines, methyl methacrylate, ethers and hydrides, aldehydes, polyolefins, chloromethanes, epichlorohydrin, chlorine, hydrogen peroxide, thiols, etc.

In South Charleston are production and consumption plants (Union Carbide, and FMC). Plastics, PVC, antifreeze, molecular chlorine and halogenated organics, carbon disulfide, peroxides, etc. are the predominant chemicals produced here. The major facility in Institute is Union Carbide which also processes a broad spectrum of compounds, e.g. viscose rayon, and phthalate esters. There is also a large scale olefin processing complex and a rubber accelerator plant. These potential sources of pollutants may also be involved in photochemical reactions. Further down the Kanawha Valley near Nitro, Monsanto and FMC have plants for the production of antioxidants, rubber accelerators, and other materials.

Because of the combination of petroleum refineries, organic chemical manufacturers, automobile exhaust, high humidity and strong sunlight, nitrosation, ozonization and sulfonation of olefins and aromatics may occur in the Houston, TX area. Located in Pasadena are Ethyl Corporation (PVC plant), Champion Paper Co., Crown Refinery, Arco Refinery, Goodyear and Petrotex Chemicals, Charter International Refinery and Stauffer Chemical Co. Ashland Oil, Exxon Refinery, and Chemical Corp. are located in Baytown. Texas City is also highly industrialized and includes Union Carbide (producing PVC), Amoco Refinery, Texas Refinery, Marathon Oil Refinery, Monsanto, GAF, and Robinson Electric. Diamond

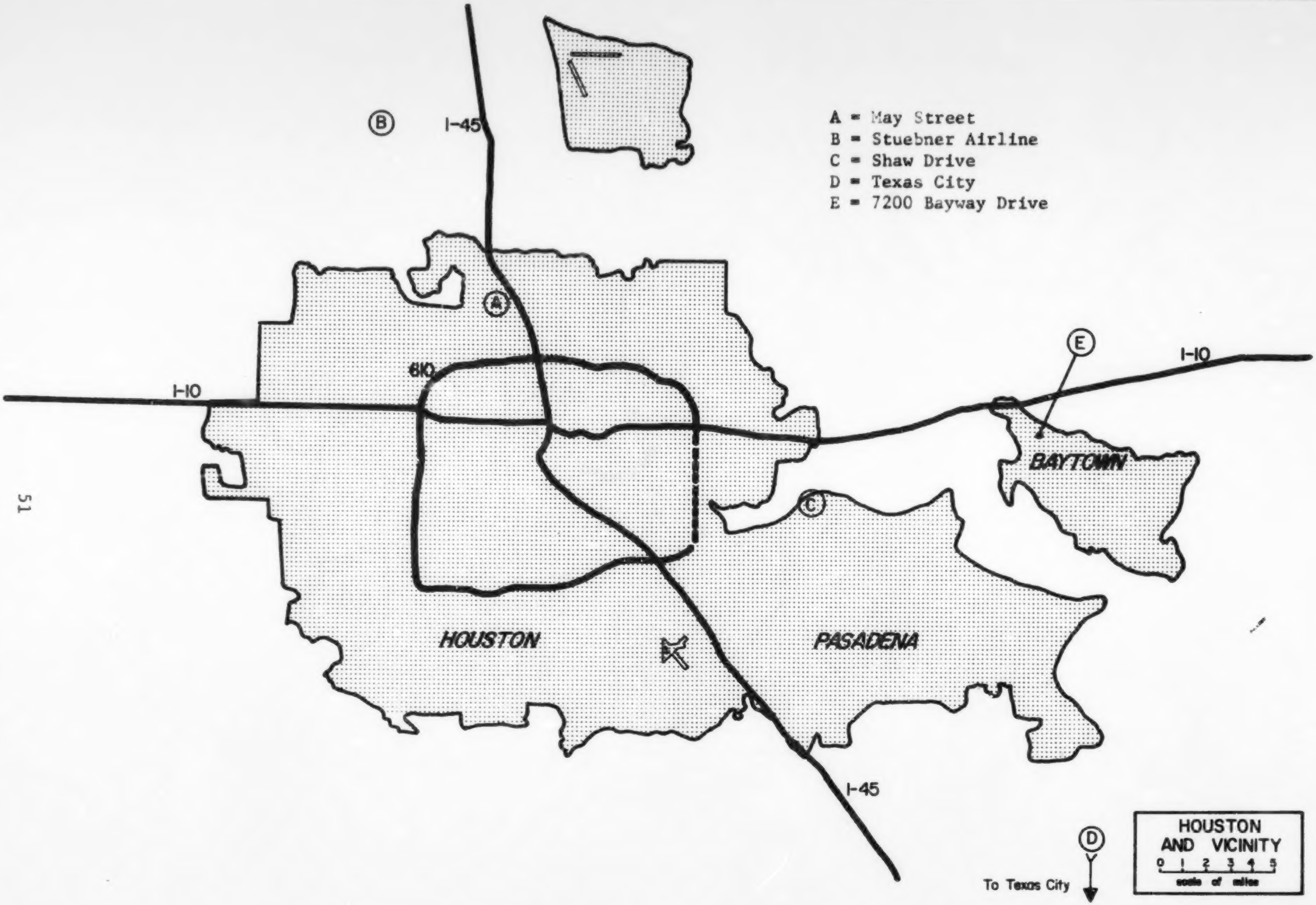

A = May Street
B = Stuebner Airline
C = Shaw Drive
D = Texas City
E = 7200 Bayway Drive
B
I-45
A
610
I-10
E
I-10
BAYTOWN
C
HOUSTON
PASADENA
I-45
D
To Texas City
HOUSTON
AND VICINITY
0 1 2 3 4 5
scale of miles

Figure 4. Map of Houston, Texas and Vicinity depicting sampling sites

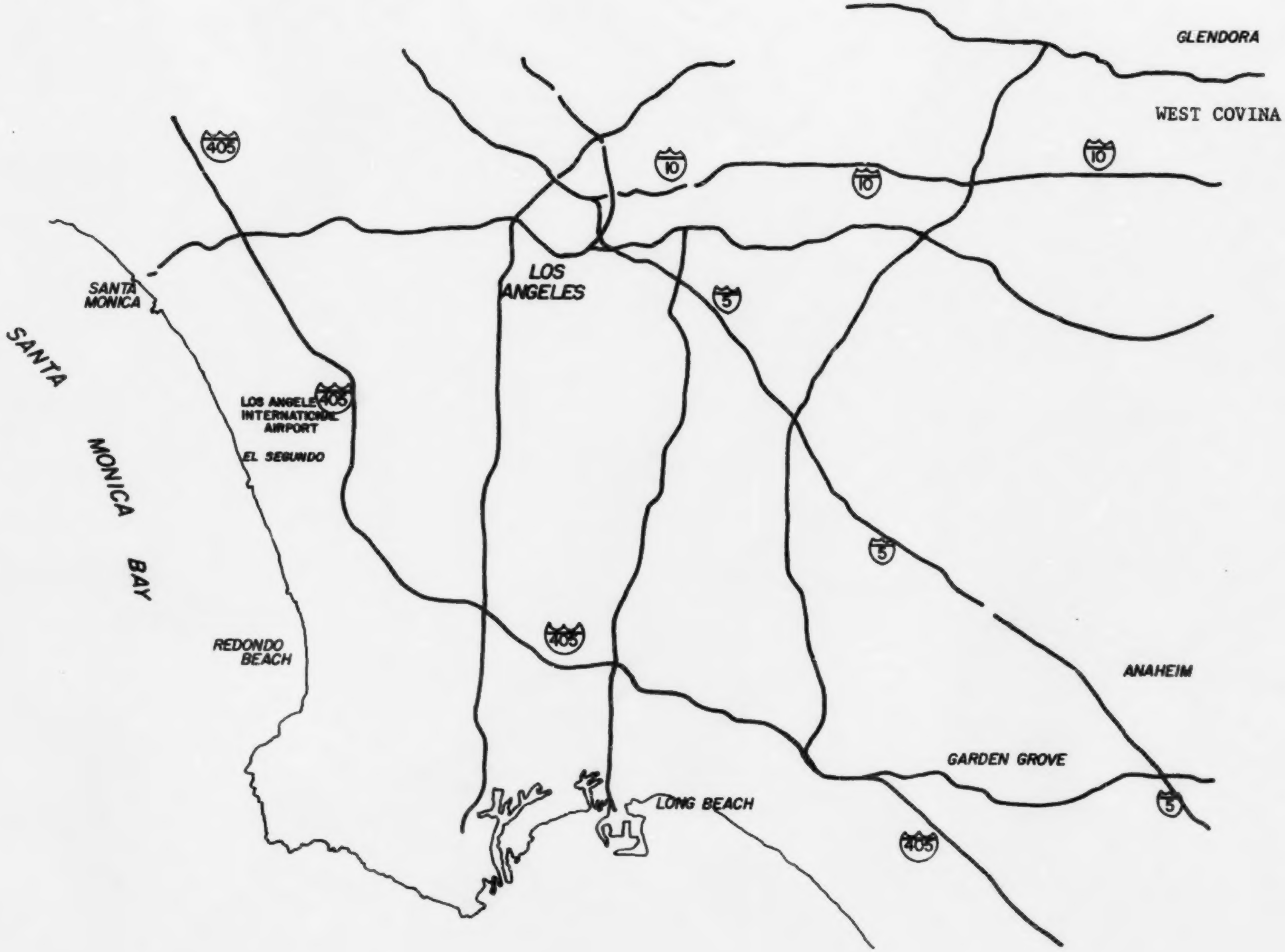

GLENDORA
WEST COVINA
10
10
10
405
5
LOS ANGELES
SANTA MONICA
SANTA MONICA BAY
405
LOS ANGELES INTERNATIONAL AIRPORT
EL SEGUNDO
5
405
REDONDO BEACH
ANAHEIM
GARDEN GROVE
LONG BEACH
5
405

Figure 5. Map of Los Angeles, CA and Vicinity depicting sampling sites.

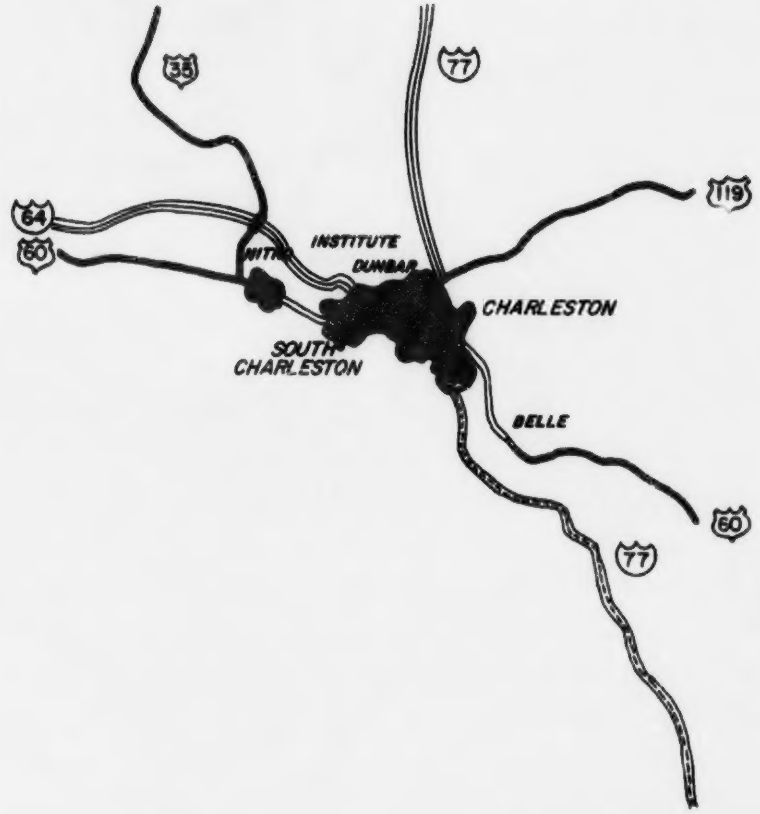

35
77
64
60
119
NITRO
INSTITUTE
DUNBAR
CHARLESTON
SOUTH CHARLESTON
BELLE
60
77

Figure 6. Map of the Kanawha Valley in West Virginia depicting sampling sites.

Shamrock Corp. (PVC plant) and Shell Chemical Co. (PVC plant) are in Deer Park, TX. Tenneco (Houston) synthesizes vinyl chloride.

The Los Angeles Basin area has been extensively studied and has served as a model for air pollution studies. This location represents an environment where photochemical smog is the predominant type of air pollution. In addition, industrial firms are located along the coast line between Long Beach and El Segundo, e.g. B. F. Goodrich Co. and American Chemical Corp. who produce PVC and vinyl chloride. The presence of olefin and aromatic hydrocarbon manufacturers along this area are potential sources for emission of primary uv absorbers which can participate in the photochemical processes in the atmosphere to yield hazardous vapors.

For these reasons, we have conducted during the past year extensive sampling, collection and qualitative analysis of ambient air pollution from these geographical areas. This section discusses these results.

Experimental

Field Sampling Protocol and Procedure

The sampling procedure employed consisted of concentrating organic vapors on a 1.5 x 6.0 cm glass cartridge containing Tenax GC (35/60). Tables 24-26 depict the sampling protocol used for the Kanawha Valley, Houston, TX area and the Los Angeles Basin.

Ambient air samples were collected with a Universal Sampler 5-1068 equipped with a Teflon® multiple-port head as previously described[14]. The glass cartridge samplers were prepared in the laboratory, transported by air freight to the various geographical locations, and, after sampling was completed, were returned also by air freight.

Sampling Analysis and Identification Techniques

The instrumental system (glc-ms-comp) used for the qualitative analysis of ambient air pollutants and the inlet manifold used for recovering vapors trapped on Tenax GC cartridge samplers were as described elsewhere[14,16]. The desorbed vapors were resolved by capillary gas-liquid chromatography and mass cracking patterns were automatically and continuously obtained throughout the glc run with a Varian CH-7 gas chromatograph/mass spectrometer. The cracking patterns and retention time data were accumulated on a magnetic tape deck and further processed

Table 24. SAMPLING PROTOCOL FOR KANAWHA VALLEY, WV

Experiment No.	Experiment Site[b]	Sampling Time (hr)	Sampling Rate 1/min	No. Cartridges[a]	m^3/Cartridge	Remarks
1	Belle, WV	2	20.8	4	2.50	8:00 a.m. - 6:00 p.m., 9/14/74, wind southeast 5-10 mph, partial overcast.
2	Belle, WV	8	36.8	2	17.64	
3	4th & C St. South Charleston, WV	2	22.9	4	2.66	8:00 a.m. - 6:00 p.m., 9/12/74, wind east 10-12 mph, partial overcast, light rain last 15 min.
4	4th & C St. South Charleston, WV	8	39.4	2	18.90	
5	11th & Myers Dunbar, WV	2	16.7	4	2.38	8:05 a.m. - 6:15 p.m., 9/11/74, heavy overcast, visibility 3-400 yds.
6	11th & Myers Dunbar, WV	8	25.9	3	12.40	
7	20 St. Nitro, WV	2	20.6	4	2.47	8:00 a.m. - 6:00 p.m., 9/13/74, foggy and wind east 10-15 mph.
8	20th St. Nitro, WV	8	38.8	2	18.60	

[a] Tenax GC cartridges (1.5 cm i.d. x 6.0 cm in length) were used.

[b] All sampling locations were at Fire Departments in these cities.

Table 25. SAMPLING PROTOCOL FOR HOUSTON, TEXAS AND VICINITY

Experiment	Site	Sampling Time (hr)	Sampling Rate 1/min	No. Cartridges[a]	m^3/Cartridge	Remarks
A	May St. Houston, TX	24	15	4	21.6	4:30 p.m. - 4:30 p.m., 11/16 - 11/7/74, heavy overcast, rain, 50-70°F.
B	Stuebner Airline Rd. Houston, TX	24	15	4	21.6	10:30 a.m. - 10:30 a.m. 11/8 - 11/9/74, cloudy, 70°F.
C[b]	Shaw Dr., Pasadena, TX	24	15	4	21.6	11:30 a.m. - 11:30 a.m., 11/11 - 11/12/74, clear, northwest wind 10-12 mph, 51-64°F.
D[b]	Texas City, TX	24	15	4	21.6	2:15 p.m. - 2:15 p.m., 11/12 - 11/13/74, clear, northwest wind 8-10 mph, 48-64°F.
E[b]	7200 Bayway Dr. Baytown, TX	24	15	4	21.6	4:30 p.m. - 4:30 p.m., 11/13 - 11/14/74, clear, south wind 10-12 mph, 45-64°F.

[a] Tenax GC cartridges (1.5 cm i.d. x 6.0 cm in length) were used.

[b] These sites were at Connie stations operated by the State of Texas Pollution Control Agency.

Table 26. SAMPLING PROTOCOL FOR LOS ANGELES BASIN AREA

Experiment[a]	Site	Sampling Time (hr)	Sampling Rate l/min	No. Cartridges	m^3/Cartridge	Remarks
1	Arizona Ave. Santa Monica, CA	8	15	4	7.2	8:50 a.m. - 5:00 p.m., 3/31/75, clear, west wind 10 mph, 55°F.
2	Phillips Ave. West Covina, CA	6.25	15	4	5.6	10:00 a.m. - 4:15 p.m., 4/1/75, partly cloudy, south wind 5 mph, 62°F.
3	East Laurel Glendora, CA	11	15	4	13.5	10:00 a.m. - 9:00 p.m., 4/2/75, sunny, no wind, 70°F.
4	West Broadway Anaheim, CA	7.5	15	4	6.75	9:30 a.m. - 5:00 p.m., 4/3/75, sunny, no wind, 70°F.
5	Nelson St. Garden Grove, CA	7.5	15	4	6.75	9:00 a.m. - 4:30 p.m., 4/4/75, cloudy, west wind 5 mph, 58°F.
6	Arizona Ave. Santa Monica, CA	15	18	3	16.2	5:00 p.m. - 8:00 a.m., 3/31 - 4/1/75, no wind, 55°F.
7	West Broadway Anaheim, CA	15.25	18	3	16.47	5:30 p.m. - 8:15 a.m., 4/3 - 4/4/75, west wind 10 mph, 65°F.

[a] Experiments 1-5 utilized 1.5 cm x 6.0 cm Tenax GC (35/60) cartridges; all samples taken during daylight hours. Experiment 6 utilized a 1.5 x 4.0 cm front (Tenax) and a 1.5 cm x 2 cm back (Chrom 104) cartridge; sampling was at night. Experiment 7 used a front and back cartridge of Chrom 104 (1.5 cm x 3.0 cm); sampling was at night. Experiment 8 was identical to No. 6.

by an on-line Varian 620i computer. Computer programs (KOSB) were employed which converted the acquired spectra into a sequential series of mass spectra and were correlated to peak retention time on a total ion current plot. Data output from the 620i computer was provided in two forms: (1) a teletype listing which contained the mass spectrum number, the number of peaks in the cracking pattern, total maximum and minimum m/e peak intensity and standard deviation from calibration m/e and (2) an electrostatic plot of total ion current plots and/or normalized mass spectra. After mass conversion of the mass cracking data, mass fragmentograms were obtained from the 620i computer.

The operating parameters for the glc-ms-comp system for the analysis of samples collected on glass cartridges from Charleston, WV, Houston, TX and Los Angeles, CA are shown in Table 27. Ambient air samples were analyzed on 200 or 400 ft SCOT columns coated with either OV-17 or OV-101 stationary phase. The desorption of ambient air pollutants from the Tenax cartridge sampler was at 265-270°C. A single stage glass jet separator interfaced the SCOT capillary columns to the mass spectrometer and was maintained at 200°C.

Identification of resolved components was achieved by comparing the mass cracking pattern of the unknown mass spectra to an eight major peak index of mass spectra[48]. In several cases the identification was confirmed by comparison with authentic compounds of the mass spectrum and the elution temperature on two different columns (OV-17 and OV-101 SCOT capillaries). Particular note was made of the relationship of the boiling point of the identified compound to its elution temperature and to its order of elution of constituents in homologous series, since the OV-101 SCOT capillary column separates primarily on the basis of boiling point.

Results and Discussion

Figure 7 represents a total ion current plot from the mass spectrometer for a Tenax GC cartridge blank which had been transported to and from Los Angeles, CA. The cartridge sampler was sealed in a Corex® centrifuge tube during transportation and served as a reference control to ensure that cartridge samplers were not contaminated during shipment by air freight. As shown in this figure, the background observed was low.

Table 27. OPERATING PARAMETERS FOR GLC-MS-COMP SYSTEM

Parameter	Setting
Inlet-manifold	
desorption chamber	265°-270°
valve	175°
capillary trap - minimum	-195°C
maximum	+175°C
thermal desorption time	~4 min
GLC	
CV-101 SCOT (200 or 400 ft) or	
OV-17 SCOT (200 ft)	
column	30 or 40-220°C, 4°C/min
carrier (He) flow	4 ml/min
MS	
single stage glass jet separator	200°C
ion source vacuum	~2 x 10^{-6} torr
filament current	300 μA
multiplier	5.5
scan rate, automatic-cyclic	1 sec/decade
scan range	m/e 20 → 300

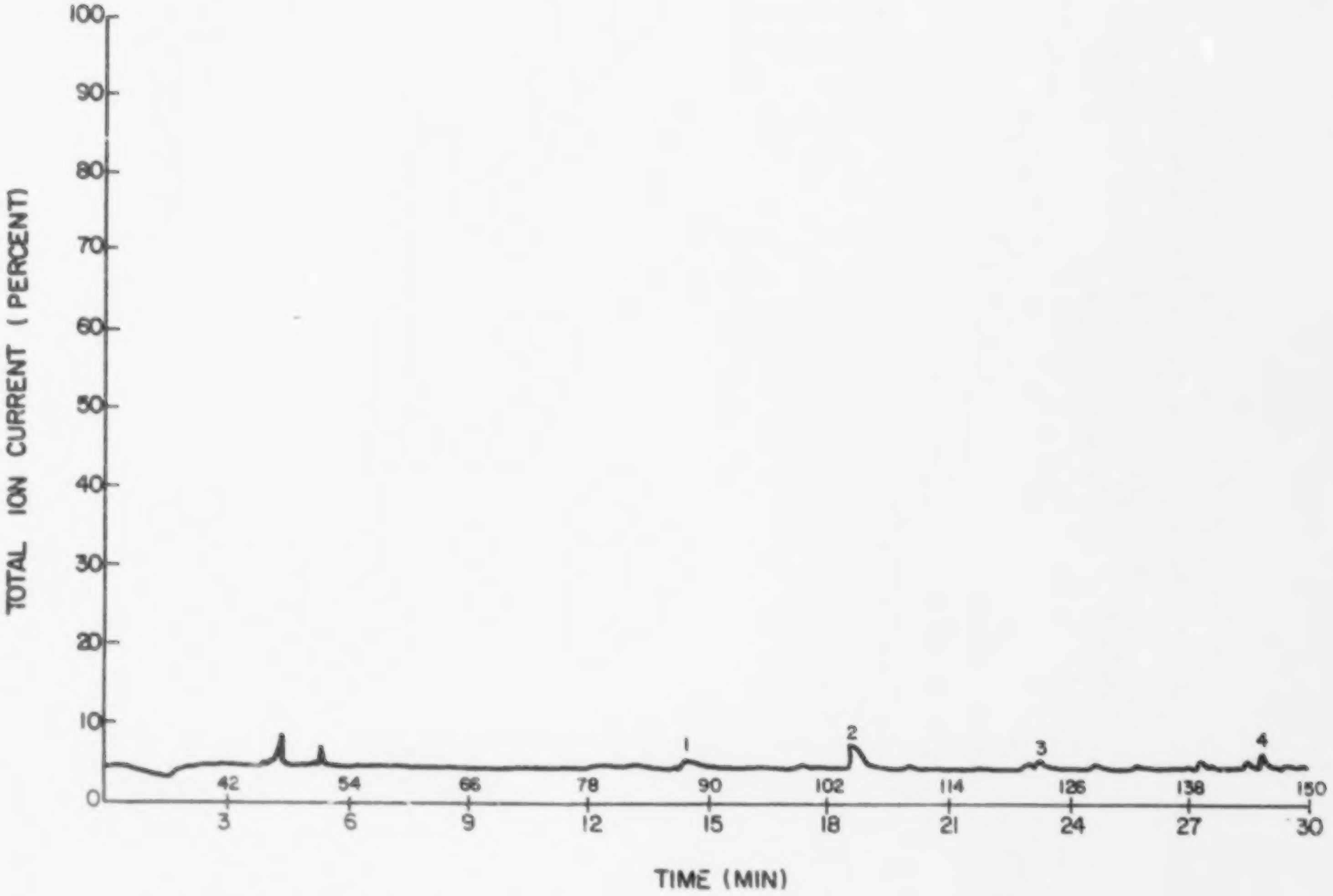


Figure 7. Total ion chromatogram of Tenax GC cartridge blank. See Table 27 for glc-ms conditions. A 400 ft OV-101 SCOT was used.

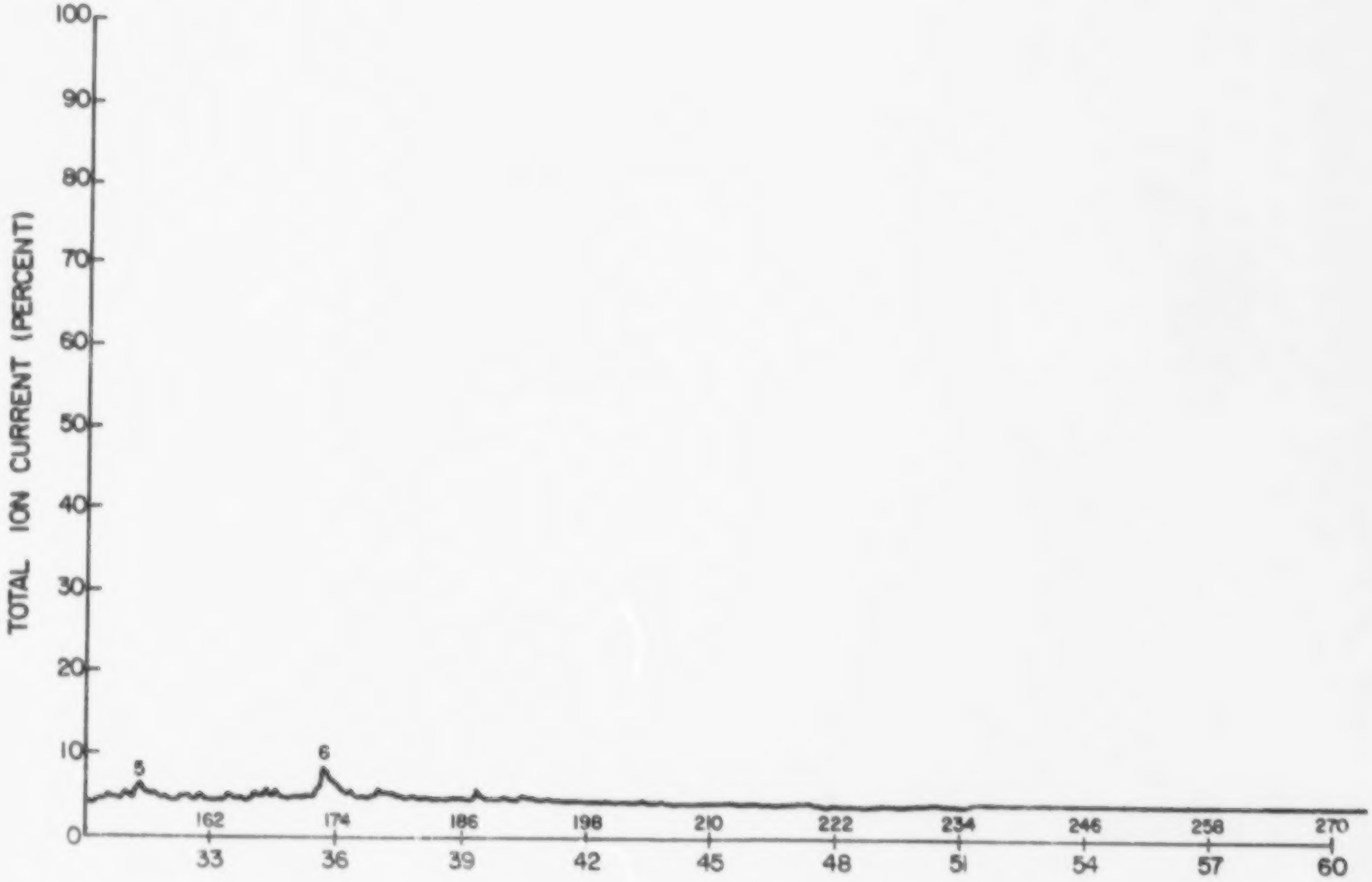


Figure 7 (cont'd)

Figures 8-12 are representative of the total ion current plots obtained for pollutants collected from the Kanawha Valley, Houston, TX area and the Los Angeles Basin. The identity of the components in Figure 8 are given in Table 53 of the Appendix. It is evident from these profiles that use of high resolution columns is imperative in order to obtain satisfactory separation of the many components in the sample. The large, broad peak which, for example, in Figure 8 occurs between 13-17 minutes represents a trace amount of water which was trapped on the Tenax cartridge. However, the presence of a small amount of water does not interfere with the mass cracking patterns or the identification of the constituents. The two SCOT columns employed in this study (OV-17 and OV-101 stationary phases) provided sufficient difference in resolution of the constituents to allow the identification of many more constituents in the sample than would have been possible by utilizing either column alone. Of the columns employed, the most useful was the 400 ft OV-101 SCOT. Additional ion current plots and the identity of the chromatographic peaks are given in the figures and tables in the Appendix to this report.

Tables 28-31 summarize the pollutants identified in air samples collected from these three geographical locations. A total of 23 halogenated hydrocarbons (Table 28) have been identified in ambient air by the described techniques of capillary gas-liquid chromatography mass spectrometry computer. Among these two are known carcinogens, vinyl chloride[5-7,49] and trichloroethylene[50-51]. The majority of compounds identified were chlorinated. To date one brominated compound (bromoform) was identified in ambient air from Houston and Los Angeles.

Many oxygenated compounds have also been discovered. A mercaptan, several alcohols, ketones, aldehydes, ethers, esters, and a phenol are represented in Table 29. Furthermore, we have tentatively identified two epoxides, epoxyheptane and styrene oxide.

Because of the generally high concentration of auto exhausts in these areas, the majority of the background pollutants were aromatic and aliphatic hydrocarbons. Tables 30 and 31 list the representative pollutants which we have identified. Two particularly interesting compounds were benzonitrile and α-cyanopyridine. The majority of the aliphatic hydrocarbons were not completely identified since it was difficult to distinguish between the

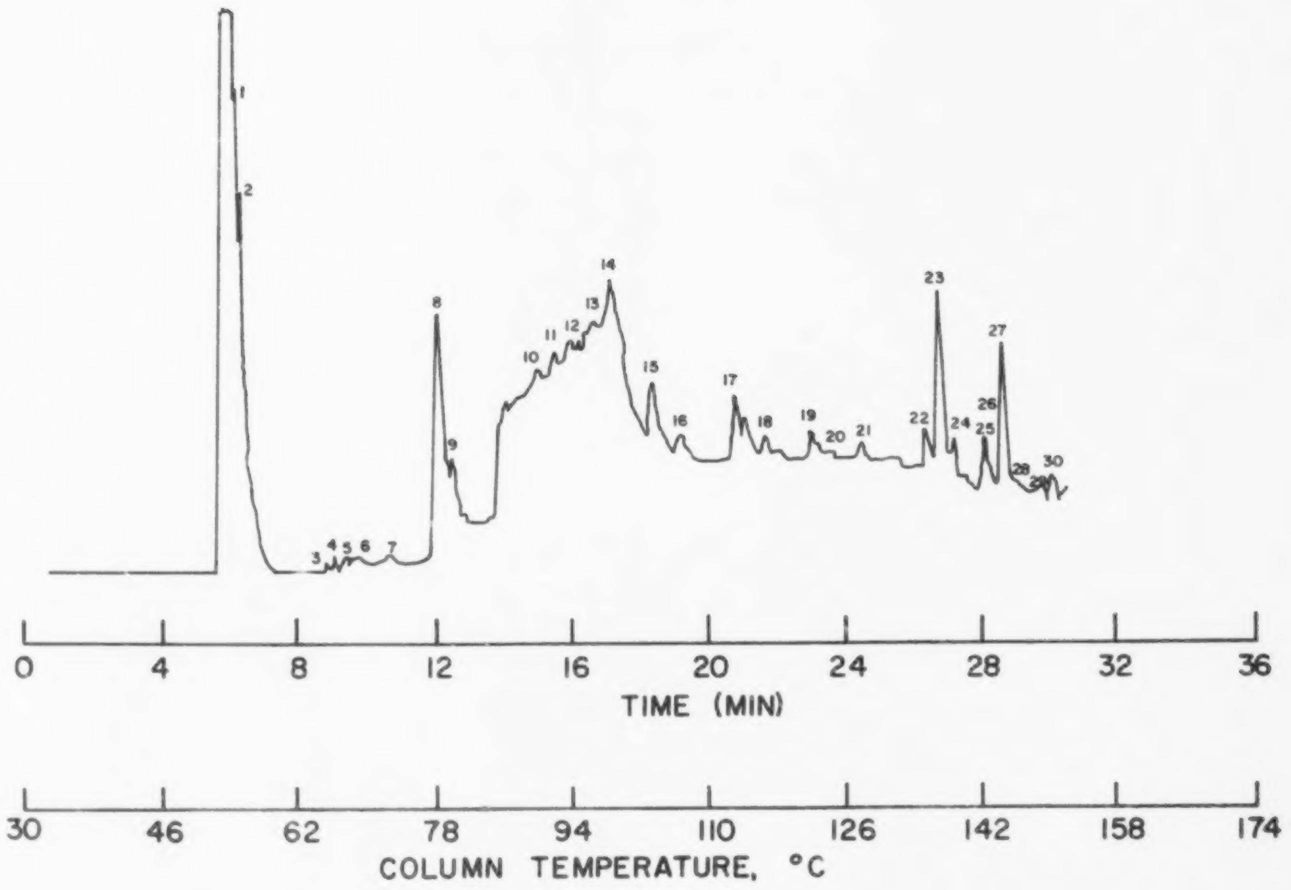


Figure 8. Total ion chromatogram of ambient air sample from South Charleston, WV. See Table 27 for glc-ms conditions and Table 53 for identity of peaks.

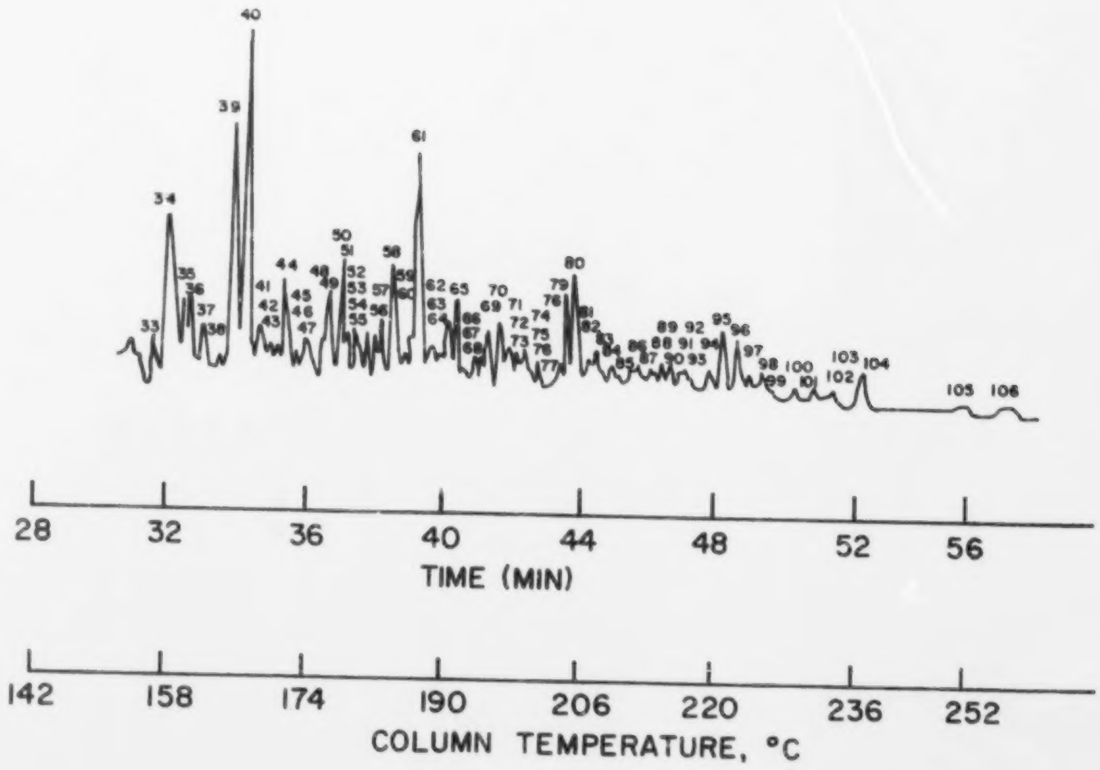


Figure 8 (cont'd)

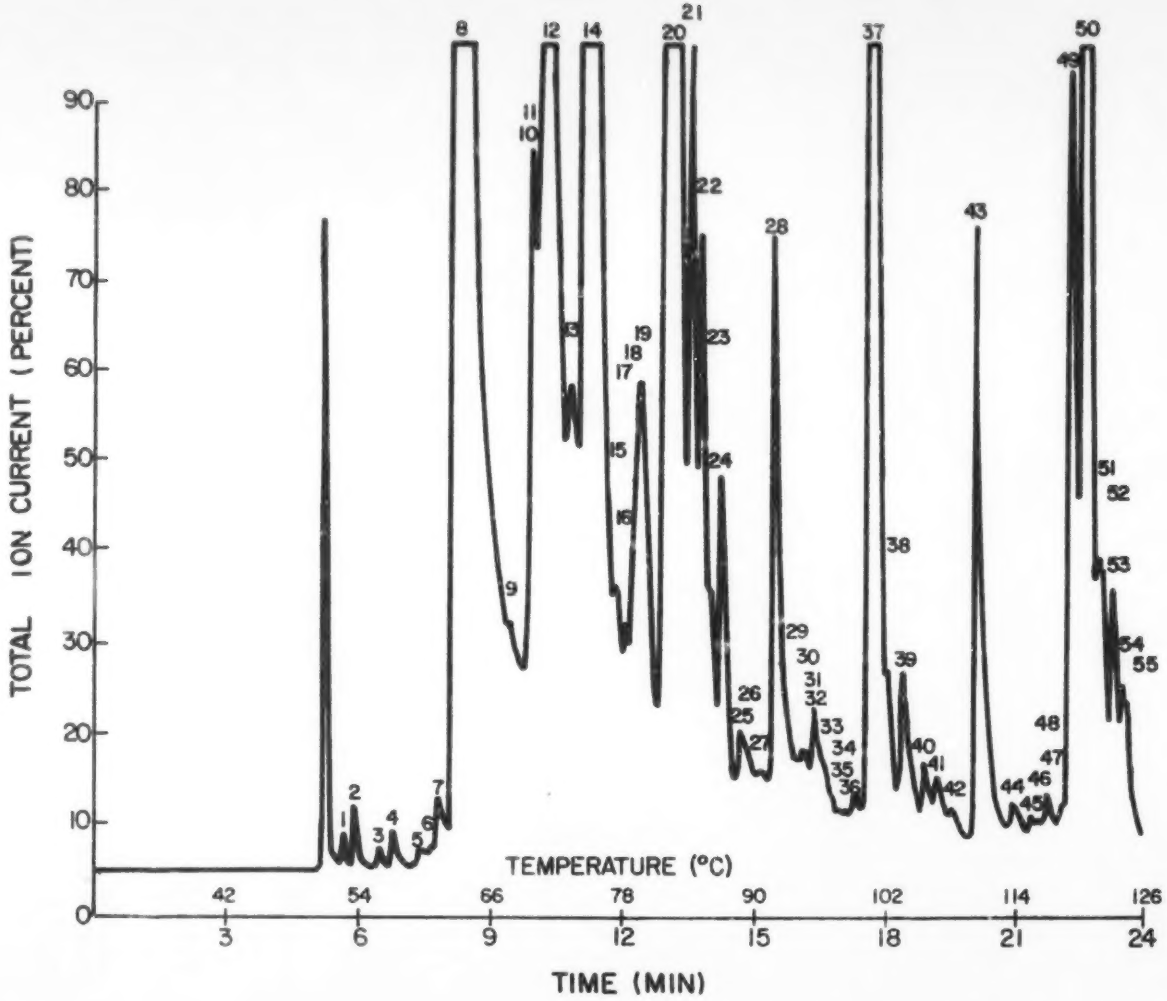


Figure 9. Total ion chromatogram of ambient air sample from Pasadena, TX. See Table 27 for glc-ms conditions and Table 48 for identity of peaks. A 200 ft OV-17 SCOT was used.

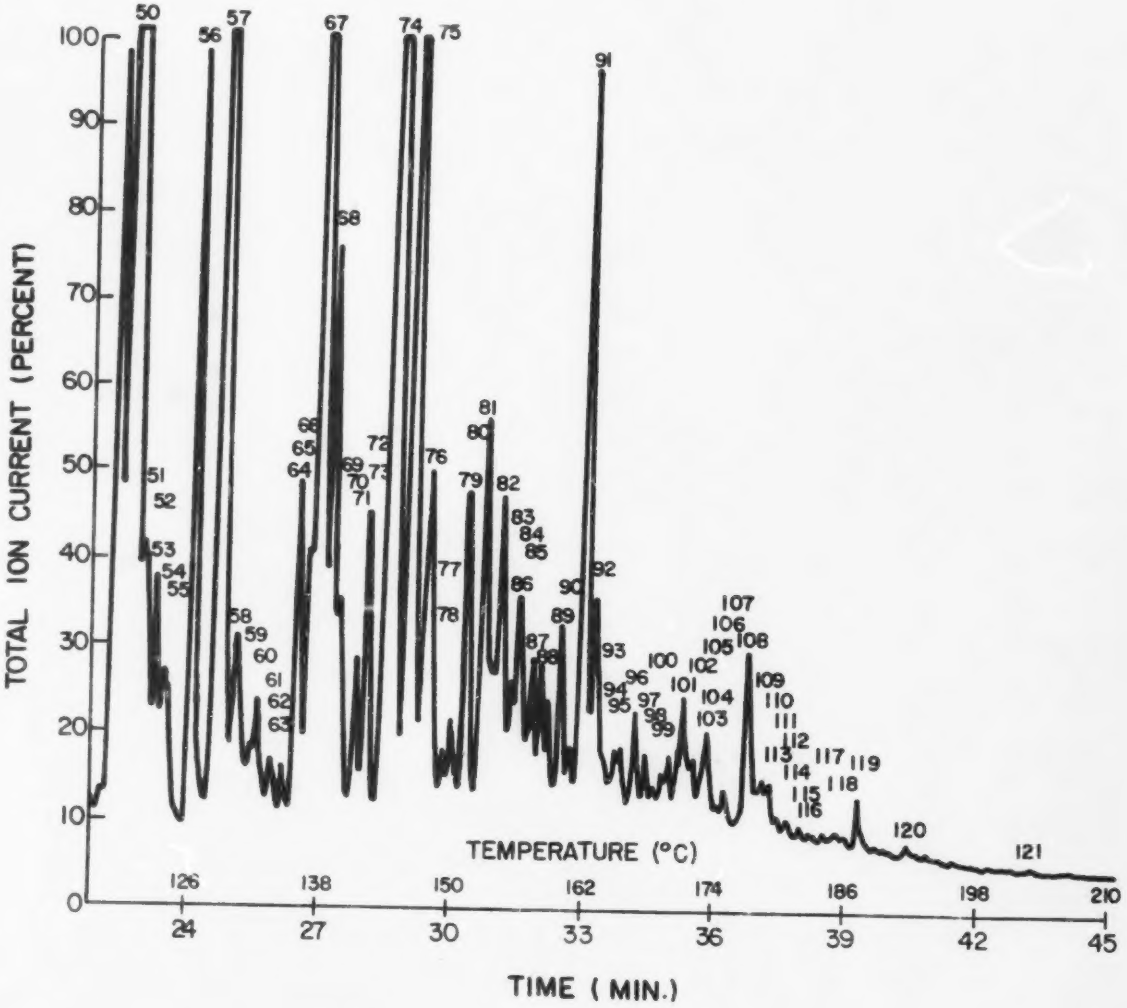


Figure 9 (cont'd)

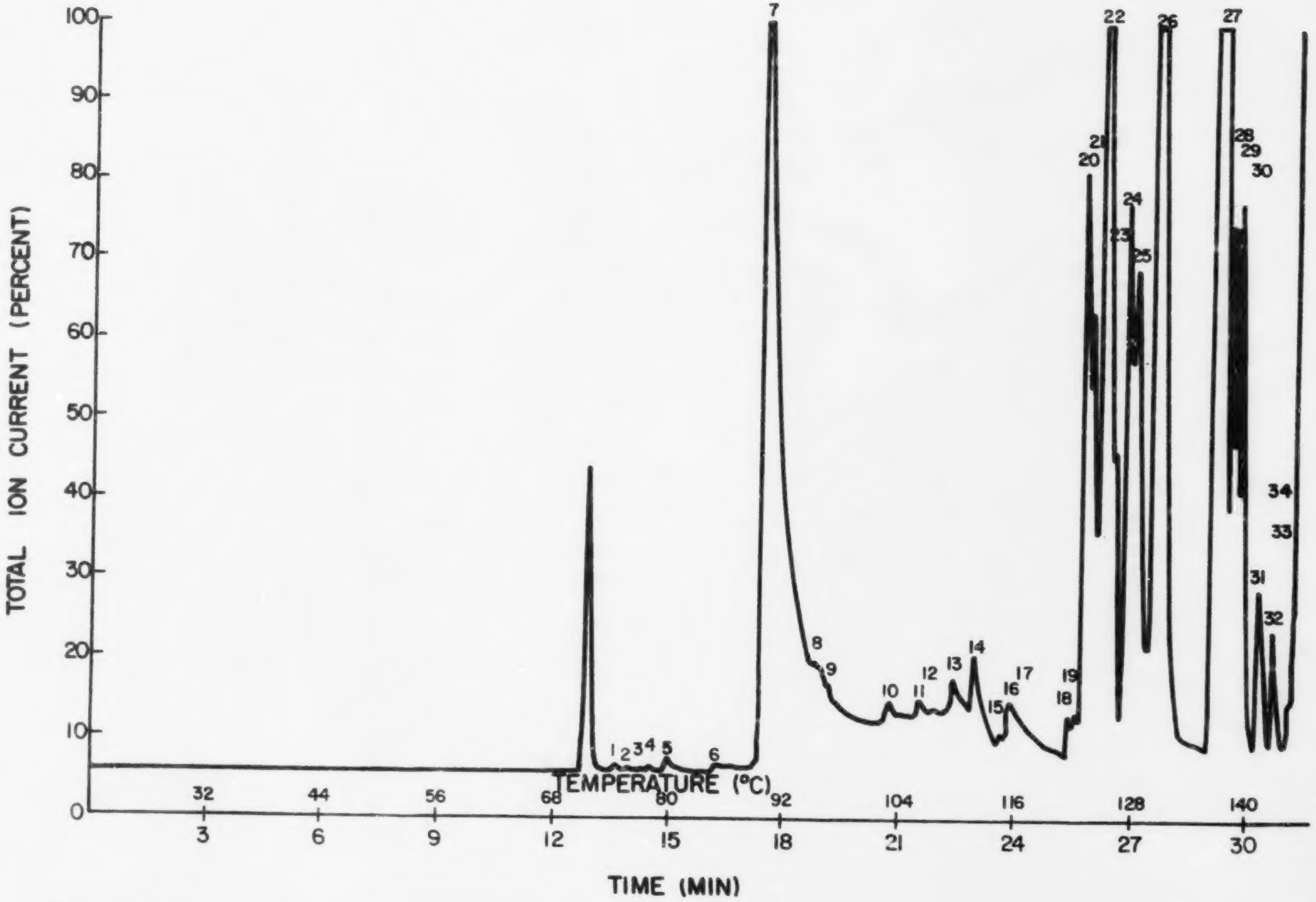


Figure 10. Total ion chromatogram of ambient air sample from Pasadena, TX. See Table 27 for glc-ms conditions and Table 51 for identity of peaks. A 400 ft OV-101 SCOT was used.

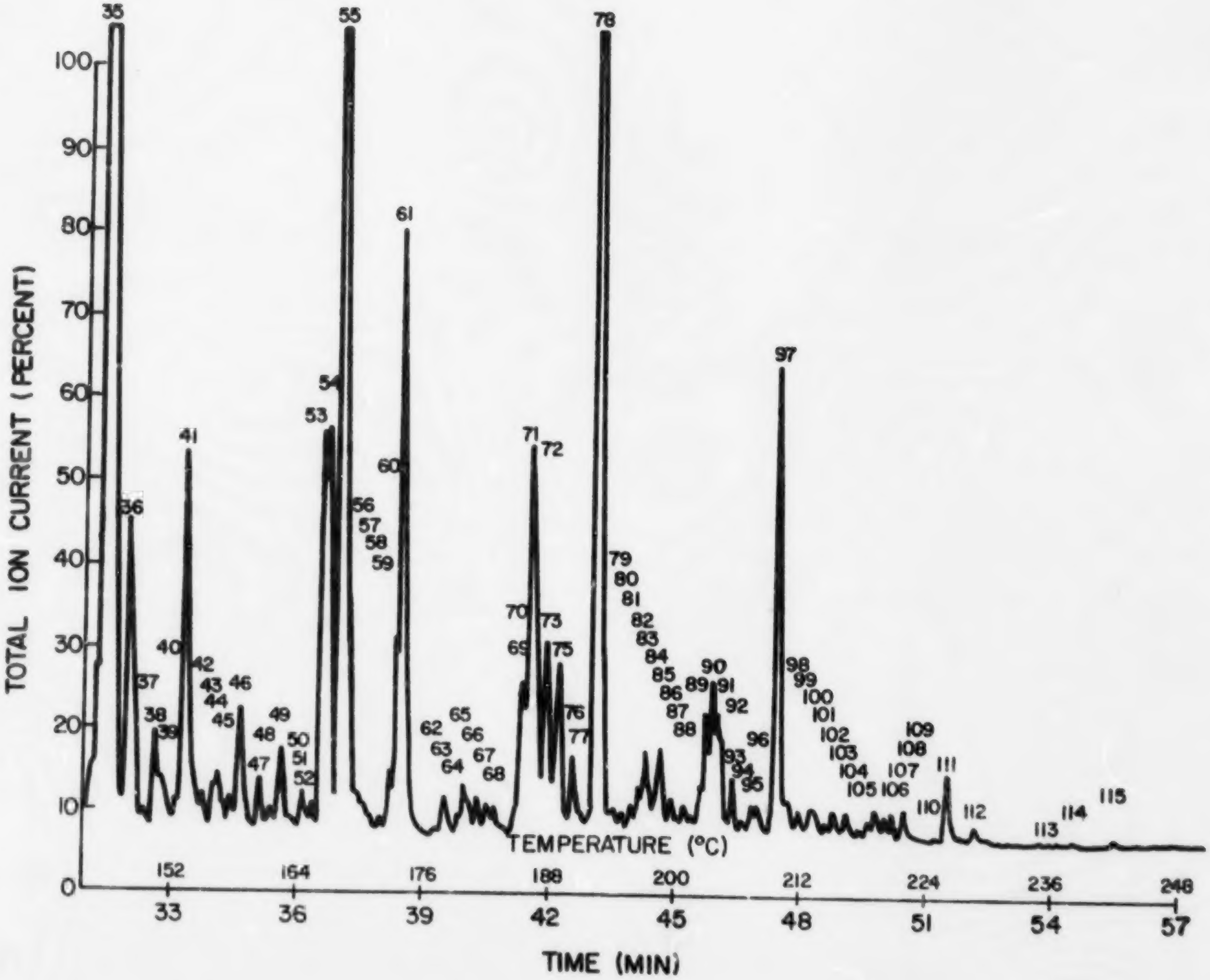


Figure 10 (cont'd)

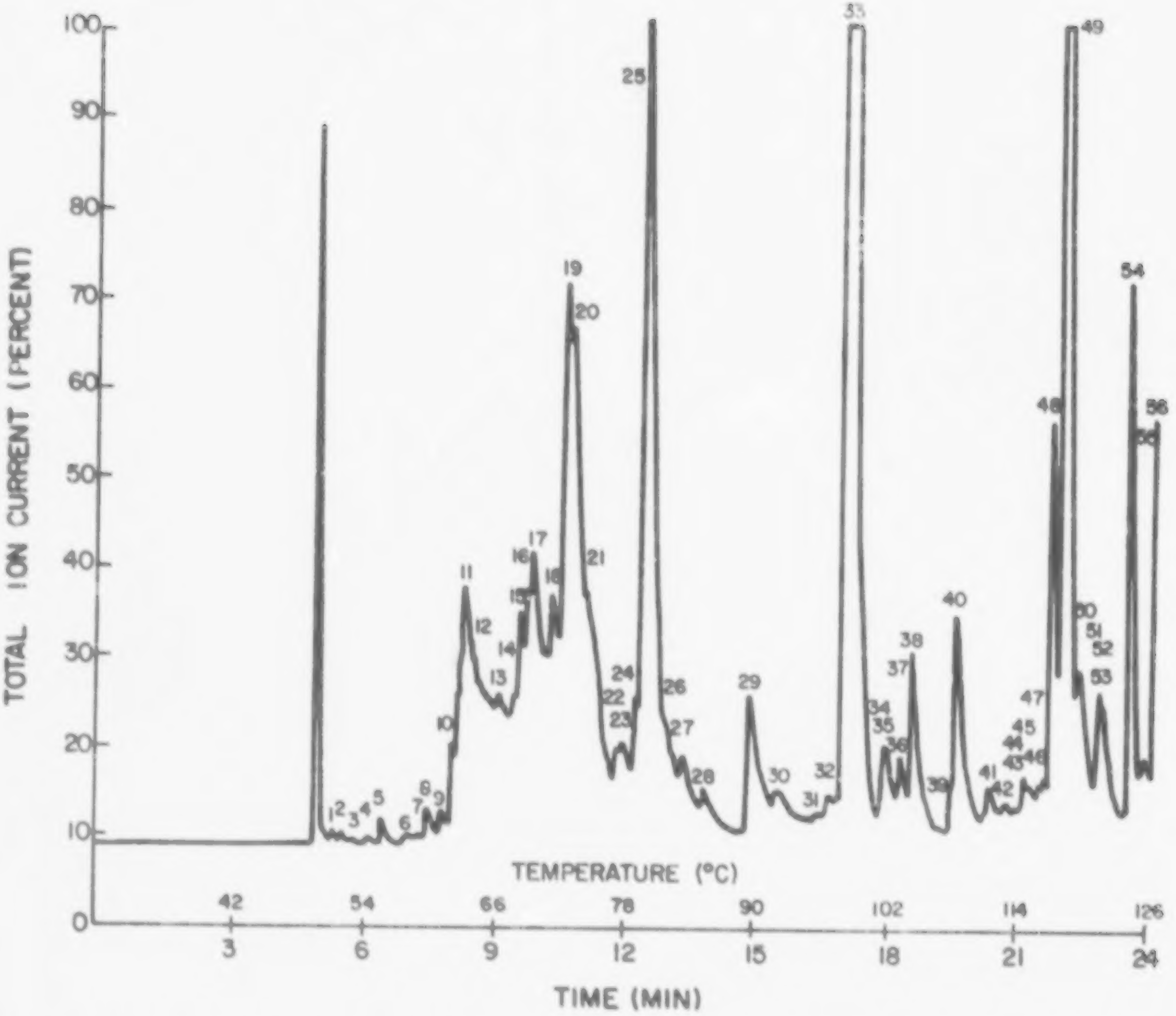


Figure 11. Total ion chromatogram of ambient air sample from Glendora, CA. See Table 27 for glc-ms conditions and Table 37 for identity of peaks. A 200 ft OV-17 SCOT was used.

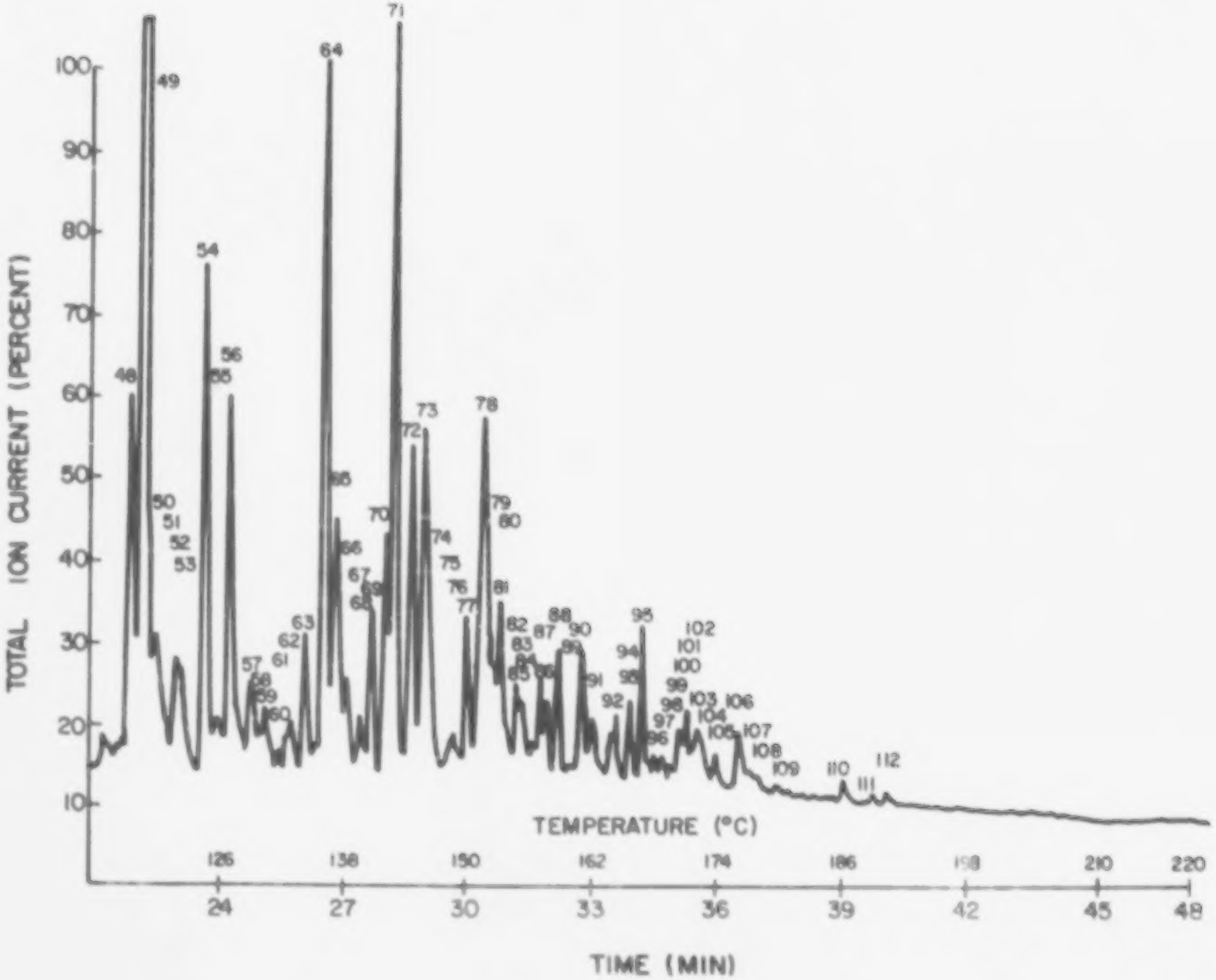


Figure 11 (cont'd)

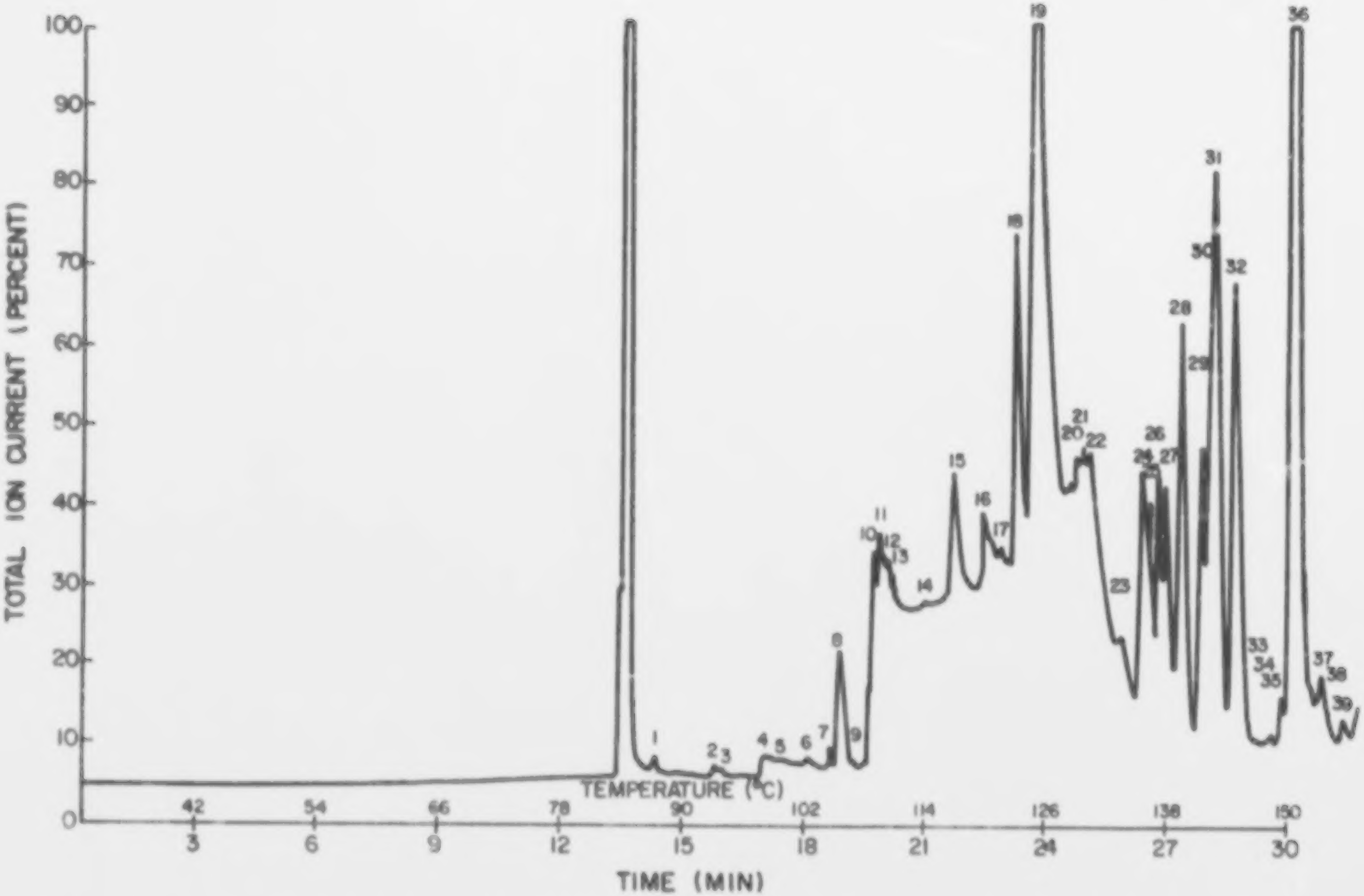


Table 12. Total ion chromatogram of ambient air sample from Glendora, CA. See Table 27 for glc-ms conditions and Table 44 for identity of peaks. A 400 ft OV-101 was used.

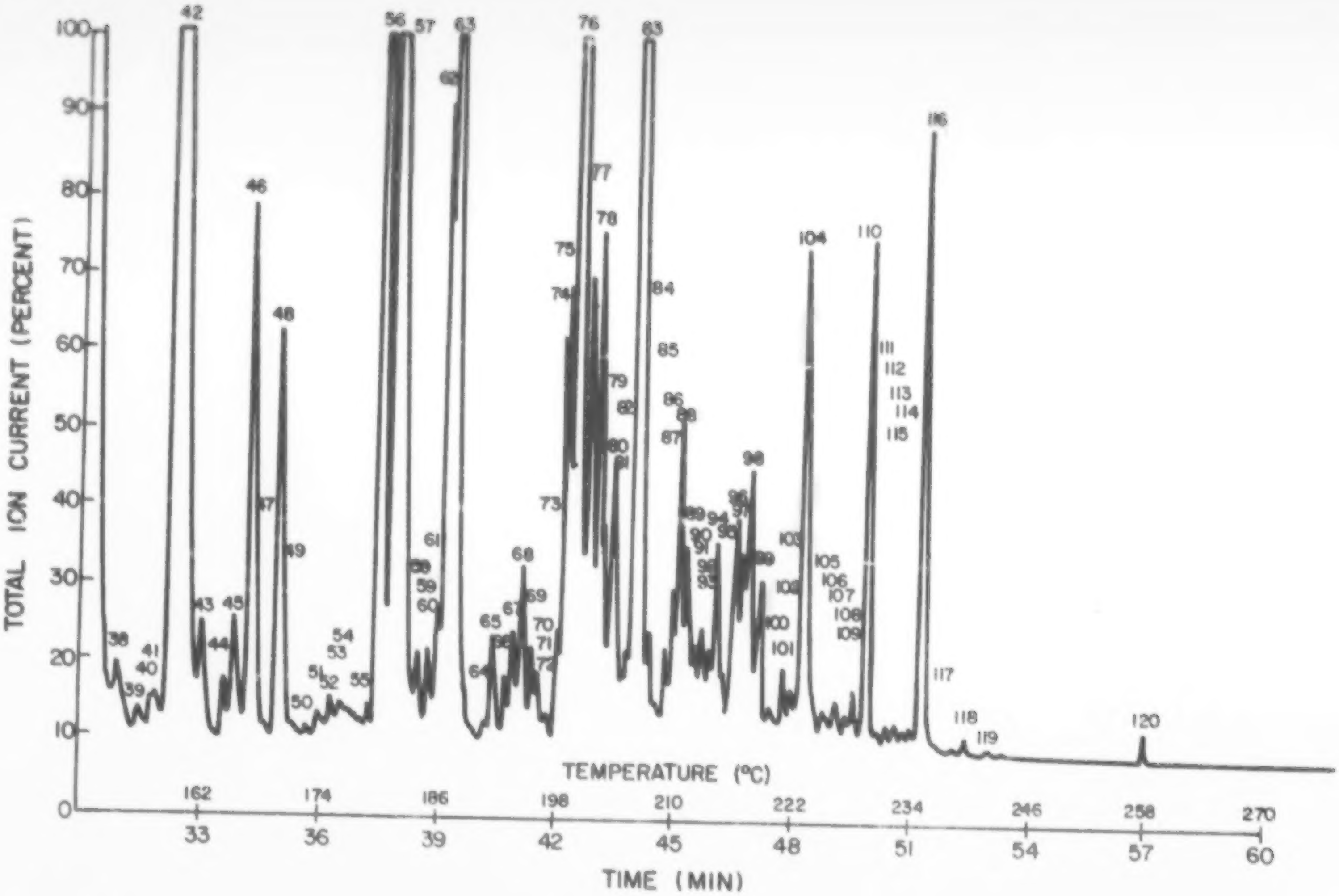


Figure 12 (cont'd)

Table 28. HALOGENATED HYDROCARBONS IDENTIFIED IN AMBIENT AIR BY CAPILLARY GAS-LIQUID CHROMATOGRAPHY/MASS SPECTROMETRY/COMPUTER

Compound	Geographical Area		
	Kanawha Valley, WV	Houston, TX and Vicinity	Los Angeles Basin
difluorochloromethane			x
trichlorofluoromethane			x
vinyl chloride		x	
methyl chloride		x	
ethyl chloride		x	
1,2-dichloroethane			x
fluorochloromethane			x
methylene chloride	x	x	x
chloroform	x	x	x
carbon tetrachloride		x	x
trichloroethylene		x	x
1,1,1-trichloroethane		x	x
tetrachloroethylene	x	x	x
2-fluoro-2-methylpropane			x
chlorobenzene	x	x	x
m-dichlorobenzene	x	x	x
o-dichlorobenzene		x	x

Table 28 (cont'd)

Compound	Geographical Area		
	Kanawha Valley, WV	Houston, TX and Vicinity	Los Angeles Basin
trichlorobenzene (probably 1,2,4)	x		x
trichlorobenzene (? isomer)	x	x	x
bromoform		x	x
1,2,3,3-tetrachloropropene		x	

Table 29. OXYGENATED ORGANIC VAPORS IN AMBIENT AIR IDENTIFIED BY CAPILLARY GAS-LIQUID CHROMATOGRAPHY/MASS SPECTROMETRY/COMPUTER

Compound	Geographical Area		
	Kanawha Valley, WV	Houston, TX and Vicinity	Los Angeles Basin
acetaldehyde		x	
acetone	x		x
ethyl acetate		x	
propanal			x
amyl acetate		x	
furan		x	x
2-methylfuran			x
isopropanol			x
acetylacetone			x
styrene oxide (tent.)			x
cyclohexanol			x
p-tolualdehyde			x
ethyl hexyl ketone			x
methyl isobutyl ketone		x	
acetophenone	x	x	x
diethyl ether	x		
methyl ethyl ketone	x	x	

Table 29 (cont'd)

Compound	Geographical Area		
	Kanawha Valley, WV	Houston, TX and Vicinity	Los Angles Basin
epoxyheptane (tent.) (isomer)	x		
benzaldehyde	x	x	x
methyl vinyl ketone (tent.)			x
n-butyl vinyl ether		x	
4-phenylbutan-2-none		x	
p-methylanisole		x	
2-methylbenzo-(B)-furan		x	
methyl phthalide		x	
2,6-ditertiary-butyl-p-cresol			x
dimethyl disulfide		x	x

Table 30. AROMATIC HYDROCARBONS IDENTIFIED IN AMBIENT AIR BY CAPILLARY GAS-LIQUID CHROMATOGRAPHY/MASS SPECTROMETRY/COMPUTER

Compound	Geographical Area		
	Kanawha Valley, WV	Houston, TX and Vicinity	Los Angeles Basin
benzene	x	x	x
toluene	x	x	x
p-xylene	x	x	x
m-xylene	x	x	x
n-propylbenzene	x	x	x
isopropylbenzene	x	x	x
p-ethyltoluene	x	x	x
1,3,5-trimethylbenzene	x	x	x
o-ethyltoluene	x	x	x
1,2,4-trimethylbenzene	x	x	x
1,2,3-trimethylbenzene	x	x	x
t-butylbenzene	x	x	x
iso-butylbenzene	x	x	x
sec-butylbenzene	x	x	x
β-methylstyrene	x	x	x
o-cymene	x	x	x
m-diethylbenzene	x	x	x
m-propyltoluene	x	x	x
n-butylbenzene	x	x	x
p-propyltoluene	x	x	x

Table 30 (cont'd)

Compound	Geographical Area		
	Kanawha Valley, WV	Houston, TX and Vicinity	Los Angeles Basin
o-diethylbenzene	x	x	x
p-diethylbenzene	x	x	x
styrene		x	x
o-propyltoluene	x	x	x
1,3-dimethyl-5-ethylbenzene	x	x	x
1,4-dimethyl-2-ethylbenzene	x	x	x
1,3-dimethyl-4-ethylbenzene	x	x	x
1,2-dimethyl-4-ethylbenzene	x	x	x
1,2-dimethyl-3-ethylbenzene	x	x	x
1,3-dimethyl-2-ethylbenzene	x	x	x
1-phenyl-2-butene			x
1-methyl-3-t-butyl benzene			x
naphthalene	x	x	x
β,β-dimethylstyrene		x	x
C_5-alkyl benzenes (13 isomers)	x	x	x
benzonitrile	x	x	x
α-cyanopyridine		x	
allylbenzene		x	
phenylacetylene		x	x

Table 31. ALIPHATIC HYDROCARBONS DETECTED AND/OR IDENTIFIED IN AMBIENT AIR BY CAPILLARY GAS-LIQUID CHROMATOGRAPHY/MASS SPECTROMETRY/COMPUTER

Compound	Geographical Area		
	Kanawha Valley, WV	Houston, TX and Vicinity	Los Angeles Basin
2-methylpropane		x	
2-methylpropene		x	
2-methylbutane		x	
n-butane	x		x
n-butene			x
isopentane	x		x
n-pentane	x		x
2,3-trimethylbutane		x	x
methylcyclopentane	x	x	x
2,2,3-trimethylbutane		x	x
2-pentyne			x
2-methylpentane	x	x	x
3-methylpentane	x	x	x
2,3-dimethylpentane	x	x	x
3-ethylpentane	x	x	x
3-methylhexane	x	x	x
n-hexane	x	x	x
C_6H_{12}	x (1)	x (1)	x (1)

Table 31 (cont'd)

Compound	Geographical Area		
	Kanawha Valley, WV	Houston, TX and Vicinity	Los Angeles Basin
C_6H_{14}	x (4)		
n-heptane	x	x	x
C_7H_{14}	x (1)	x (3)	x (1)
C_7H_{16}	x (3)	x (4)	x (5)
n-octane	x	x	x
C_8H_{16}		x (12)	x (3)
C_8H_{18}		x (8)	x (8)
n-nonane	x	x	x
C_9H_{18}	x (2)	x (5)	x (2)
C_9H_{20}	x (6)	x (8)	x (8)
n-decane	x	x	x
$C_{10}H_{20}$		x (2)	x (2)
$C_{16}H_{22}$		x (8)	x (10)
$C_{11}H_{22}$		x (11)	x (5)
$C_{11}H_{24}$	x (6)	x (9)	x (9)
$C_{12}H_{24}$			
$C_{12}H_{26}$	x (2)	x (5)	x (1)
$C_{13}H_{26}$		x (3)	x (1)
$C_{13}H_{28}$	x (3)	x (1)	
$C_{13}H_{28}$		x (1)	
$C_{14}H_{30}$		x (1)	x (2)

isomeric forms based solely on the mass cracking patterns and the retention index. Thus, in these tables we have often represented these compounds primarily as imperical formulas and the number of isomers which we detected are in parentheses.

Ambient air samples were also obtained from an area near Burlington Industries and Mallinckrodt in Raleigh, NC. The purpose of this study was to establish whether biphenyl could be collected and identified in ambient air near these two industrial firms. Biphenyl was suspected to be present in ambient air since it occurs as a by-product in a manufacturing process at Burlington Industries. Research investigators at the North Carolina State Air Pollution Agency suspect that biphenyl is responsible for the pine tree kill in the immediate area. The results of this study are shown in Figures 13-15. A total ion chromatogram of an ambient air sample near these two industries is shown in Figure 13. In general, the majority of the components in the ambient air sample represented background pollutants from auto exhuast. However, a new component appeared which is represented as peak 84 in Figure 13. The mass spectrum of this chromatographic peak is shown in Figure 14. A comparison of this mass spectrum to that of an authentic sample of biphenyl (Figure 15) was made. On the basis of these results we concluded that the peak eluting at 194° was biphenyl. A second sample was collected two and one-half months later. The chromatogram obtained utilizing a 200 ft SCOT OV-101 column is shown in Figure 27 in the Appendix. The retention time and the elution temperature of biphenyl were established in this case by comparing to an authentic sample. The concentration of biphenyl was found to be approximately 1-3 ppm at a location of one-half mile from Burlington Industries. On this particular day (maximum of 55°F) the wind speed was 10-15 mph with the sampler located down-wind from the industrial complex.

Several methods are available using gc-ms systems to quantitate constituents and complex matrices. One common method is based upon alternating the accelerating voltage (AVA) in the ion source whereby two selected m/e ions are continuously monitored throughout the chromatographic process. This technique provides an increase in sensitivity over the total ion current generated from the mass spectrometer. However, it has a serious disadvantage in that only two ions may be monitored at any particular time during gas

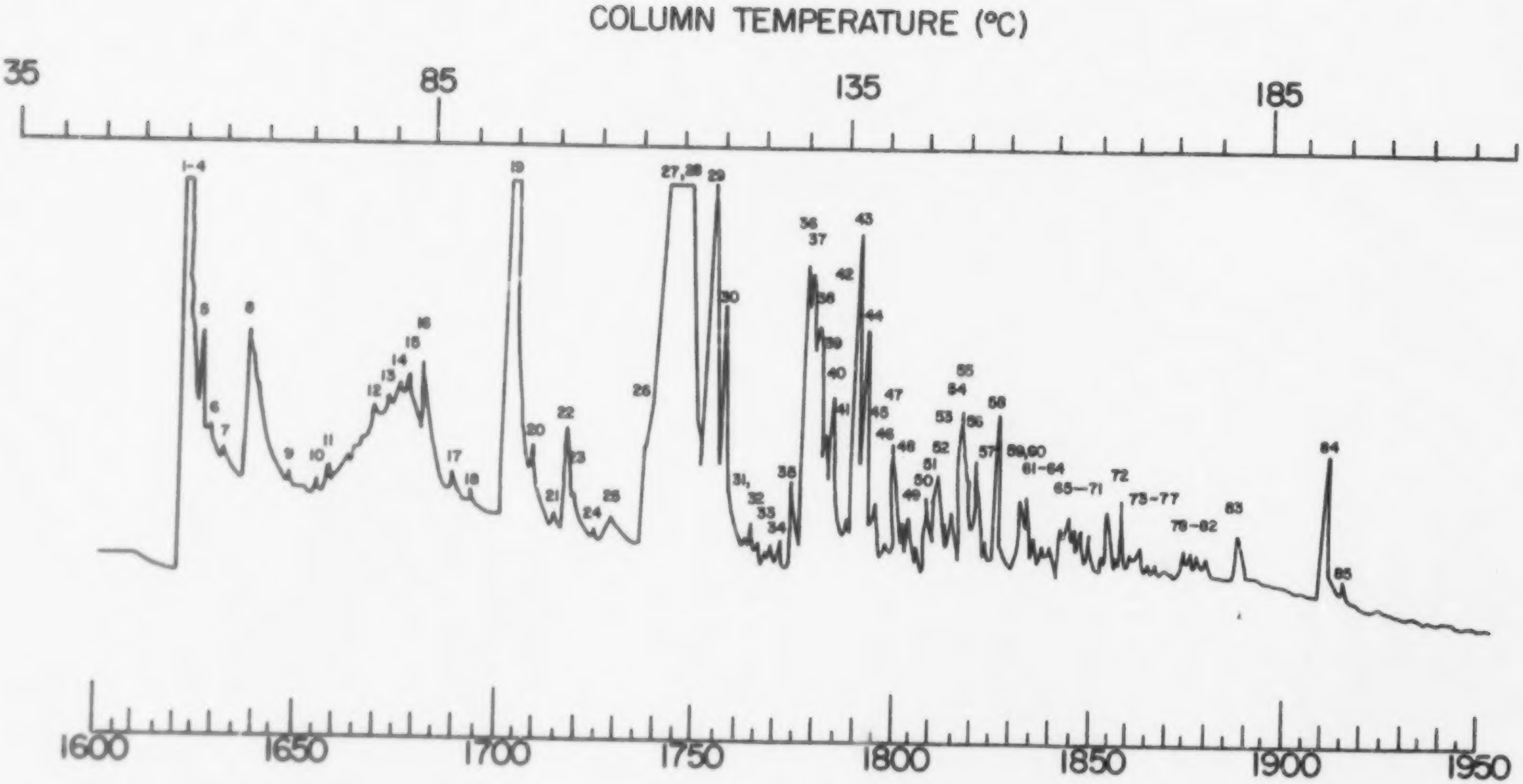


Figure 13. Total ion chromatogram of ambient air sample near Burlington Industries and Mallinckrodt in Raleigh, NC. See Table 27 for glc-ms-comp conditions.

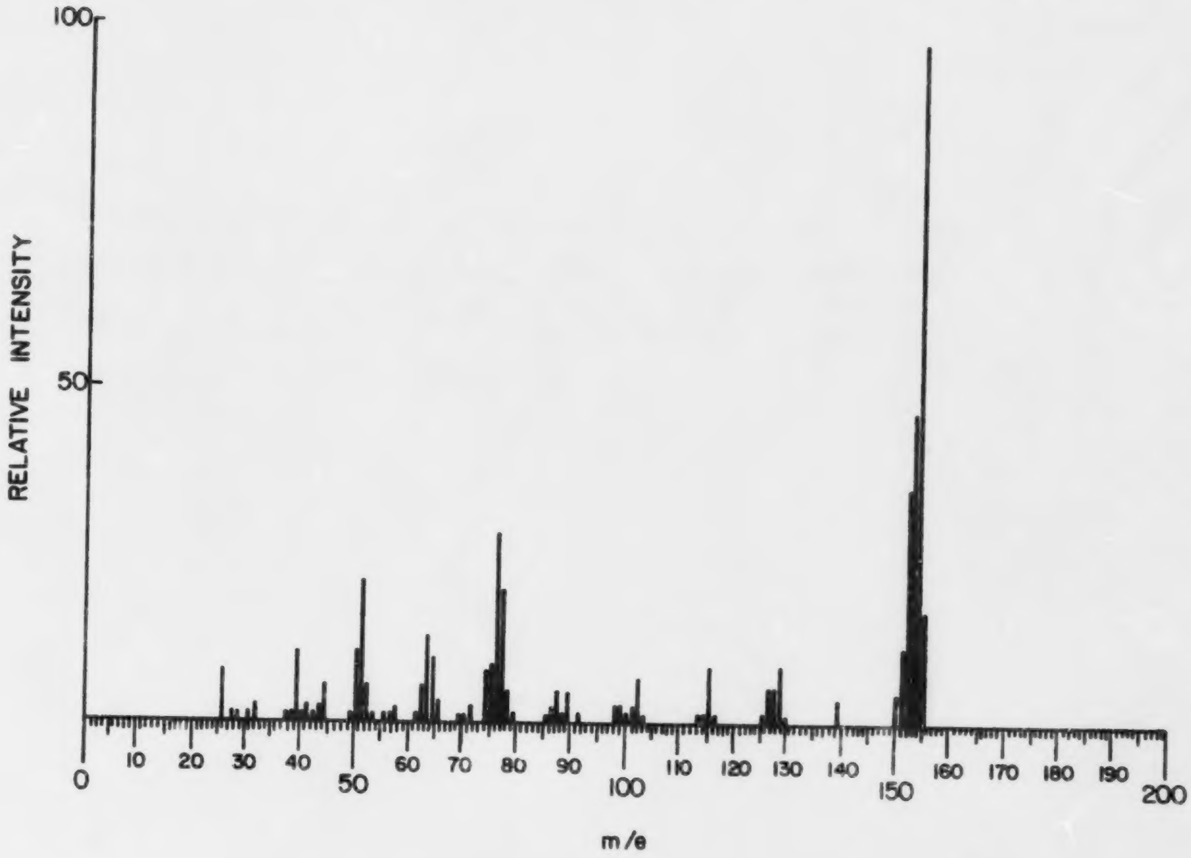


Figure 14. Mass spectrum of chromatographic peak no. 84 eluting at 194°C for previous figure.

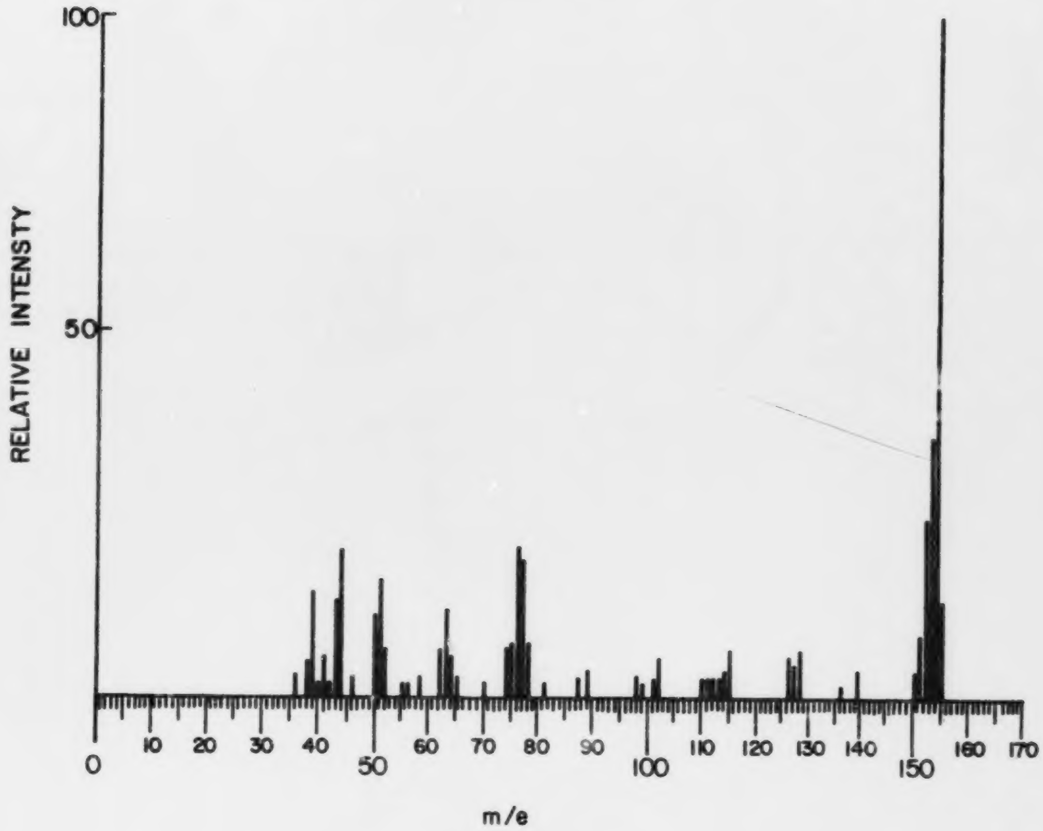


Figure 15. Mass spectrum of an authentic sample of biphenyl.

chromatography. One m/e ion usually represents the internal standard in the sample and the second is an m/e for the constituent of unknown concentration. This technique is not suitable for ambient air pollution analysis since many constituents (100-200) are present in a sample. The AVA method is generally utilized with magnetic sector mass filter instruments. For this reason, the ions selected for monitoring are required to be less than 10 atomic mass units apart in order to maintain resolution and sensitivity. A serious limitation of this technique is that the ions selected for the internal standard and the constituent to be quantitated must be derived from similar fragmentation patterns or molecular weight. Because of the large number and diverse molecular weights of the pollutants in ambient air, this technique is not feasible for quantitating more than one constituent per chromatographic run.

Another available method for quantitation is multiple ion detection (m.i.d.). This technique is used primarily on instruments equipped with quadrupole or dodecapole mass filters. Multiple ion detection is an improvement over the AVA method since up to 12 ions may be monitored simultaneously. However, because of the large number of pollutants in air, the quantitation of all constituents in the sample cannot be accomplished by m.i.d., either.

The estimation of the level of pollutants in capillary gas chromatography is not feasible utilizing the total ion current plot since baseline resolution between peaks is not achieved. On the other hand, if full mass spectra are obtained during the chromatographic separation steps and selected ions are presented as mass fragmentograms, then it is possible to deconvolute (resolve) constituents which were not resolved in the total ion current chromatogram by using software programs on the dedicated computer. Examples are shown in Figures 16 and 17. Selected ions (m/e 117, 166, 146, 83, and 49) are plotted as mass fragmentograms for an ambient air sample from Glendora, CA (Figure 12). Even though the components depicted in Figure 12 were not completely resolved into individual constitutents, it is possible to obtain baseline resolution by representing each compound as a single ion plot. In Figure 16 m/e 117 represents carbon tetrachloride (mass spectrum numbers 95-100). The m/e ions 166 and 146 represent tetrachloroethylene and m-dichlorobenzene, respectively. In Figure 17 the m/e ions 83 and 49 represent chloroform (mass spectrum numbers 88-95) and methylene chloride (mass

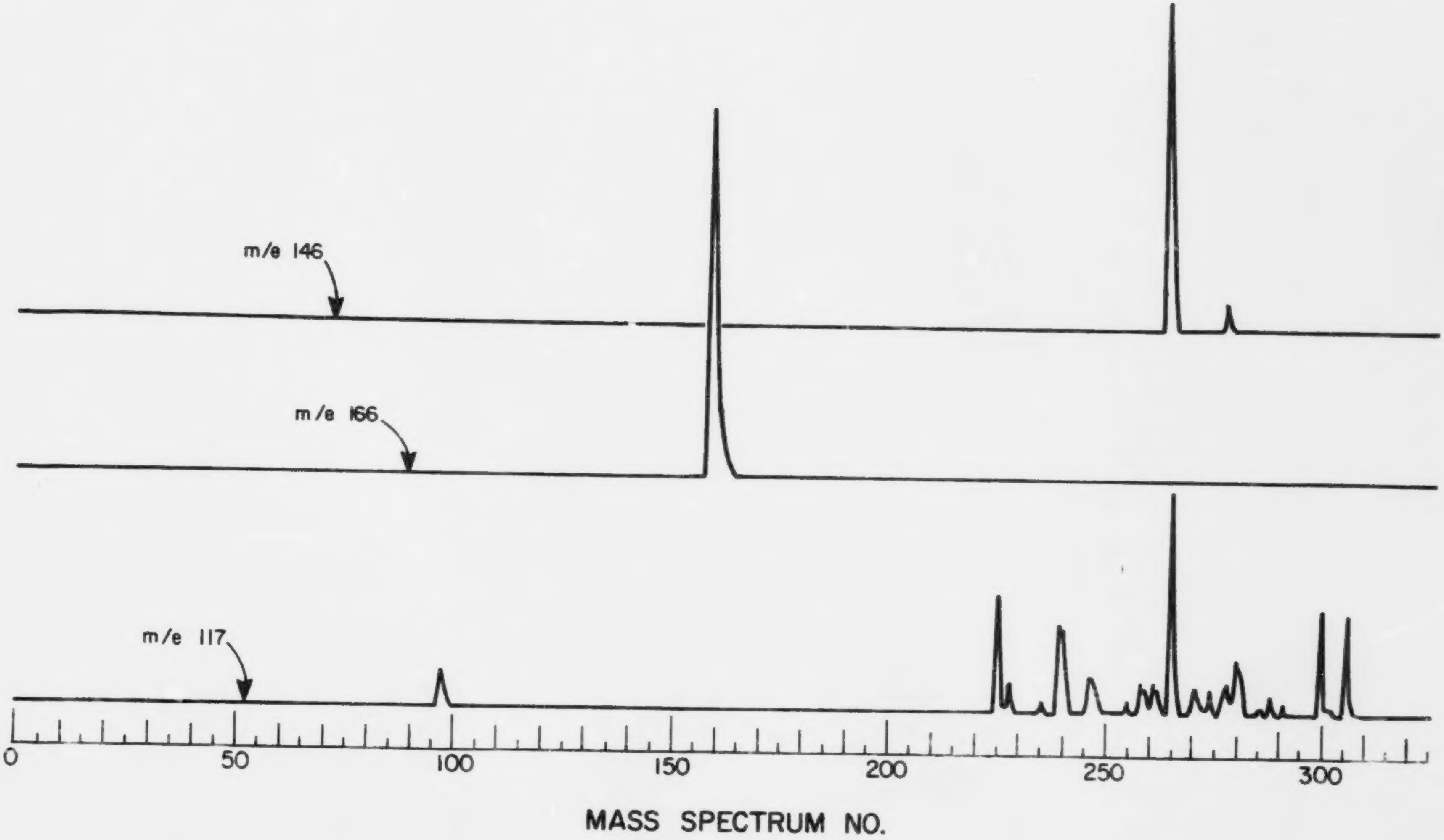


Figure 16. Mass fragmentograms of unique ions representing carbon tetrachloride (m/e 117), tetrachloroethylene (m/e 166) and m-dichlorobenzene (m/e 146) in ambient air from Glendora, CA. See Figure 12 for total ion plot.

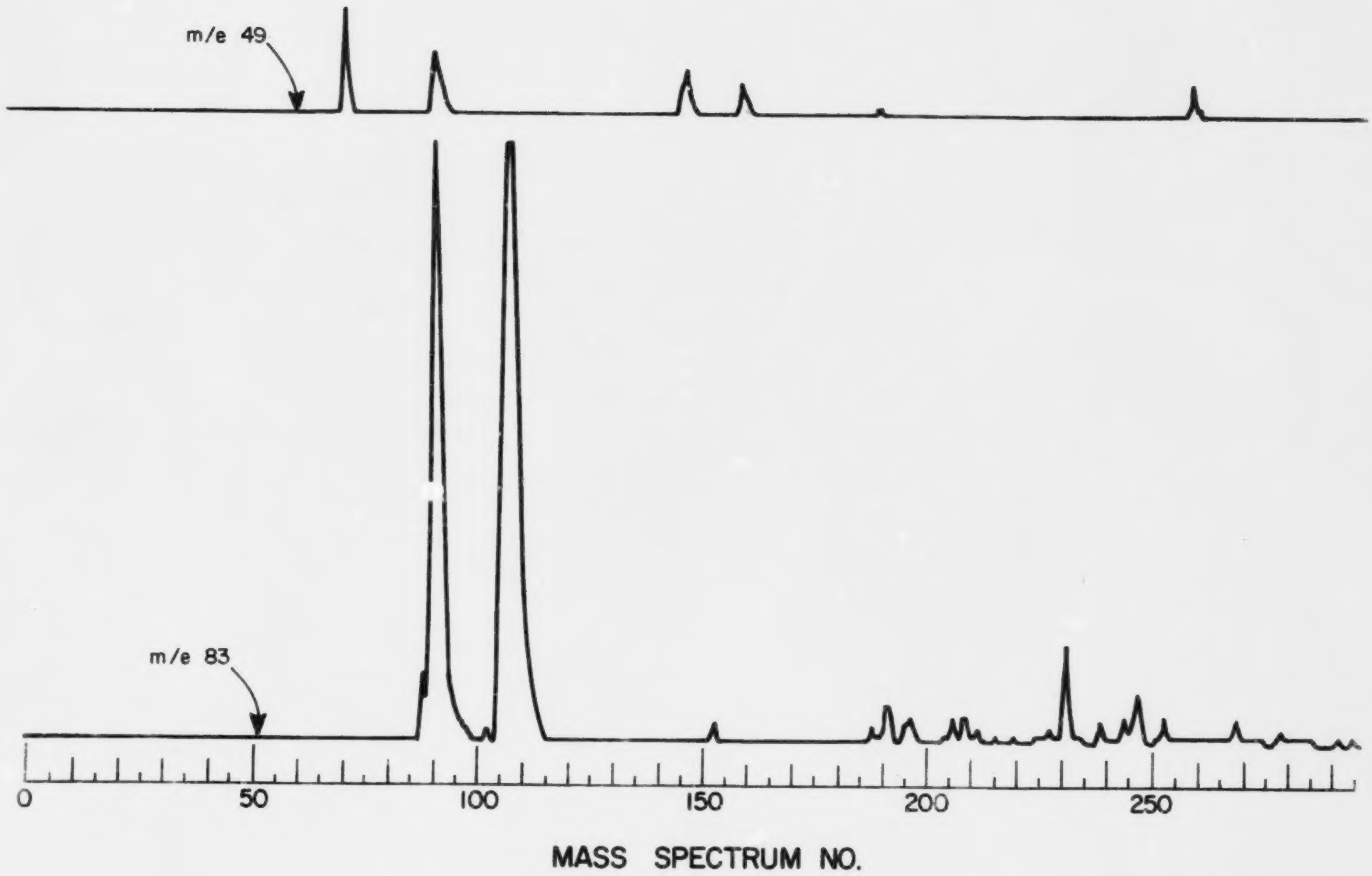


Figure 17. Mass fragmentograms of unique ions representing methylene chloride (m/e 49) and chloroform (m/e 83) in ambient air from Glendora, CA.

spectrum numbers 69-72), respectively. Even though in the total ion current plot only partial resolution was observed between many of the peaks associated with these compounds, baseline resolution with no interferences was achieved utilizing the mass fragmentogram method. In our glc-ms comp system we can request from the Varian 620i dedicated computer mass fragmentograms for any combination of m/e ions when full mass spectra are obtained during chromatography.

As other carcinogenic and mutagenic vapors are identified during the continuing contract period, hazardous vapors will be quantitated utilizing the described techniques.

SECTION VIII

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SECTION IX
APPENDIX

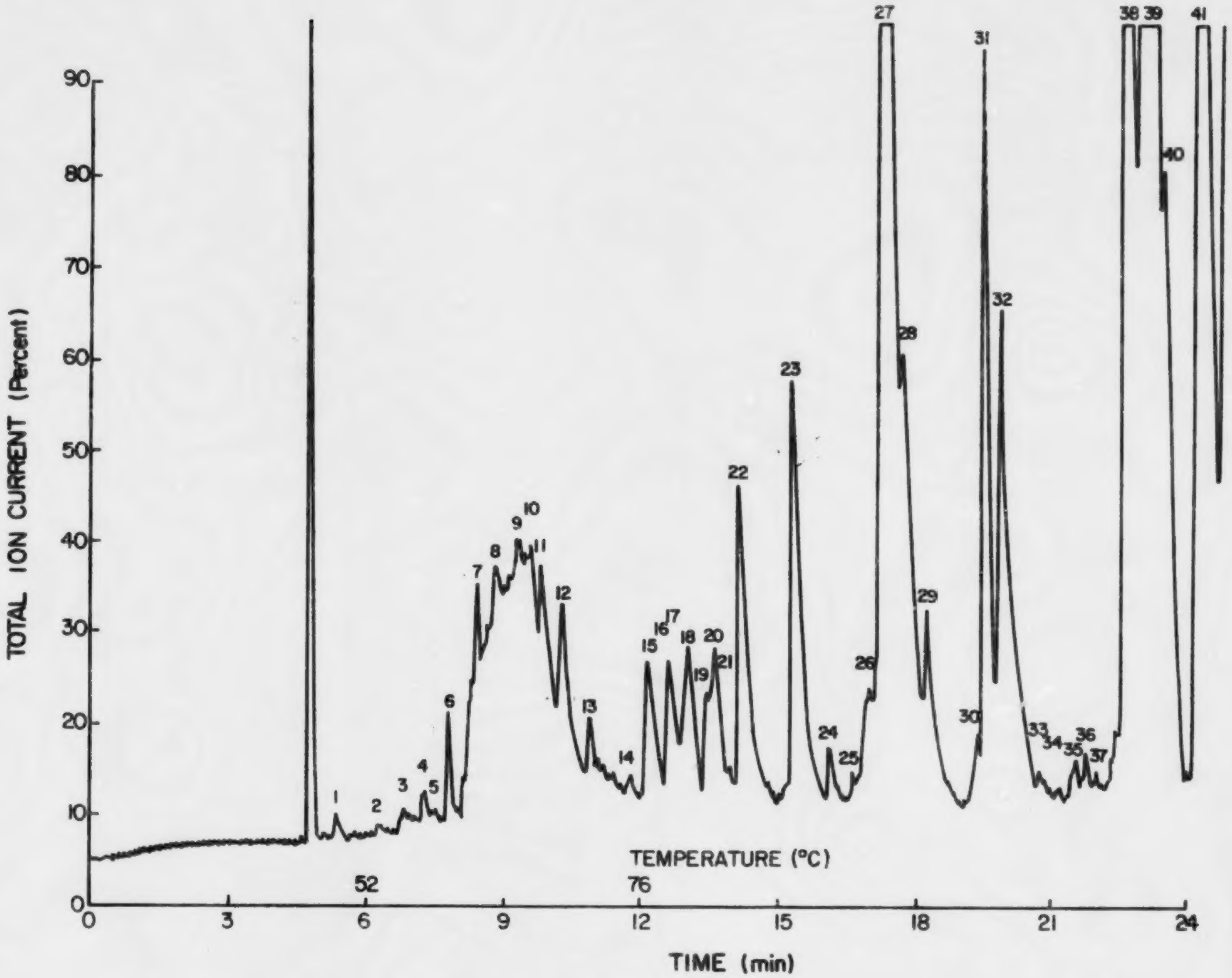

Figure 18. Total ion current plot during gas-liquid chromatography mass spectrometry of air sample from Santa Monica, CA. A 200 ft OV-101 SCOT was used, see text for conditions.

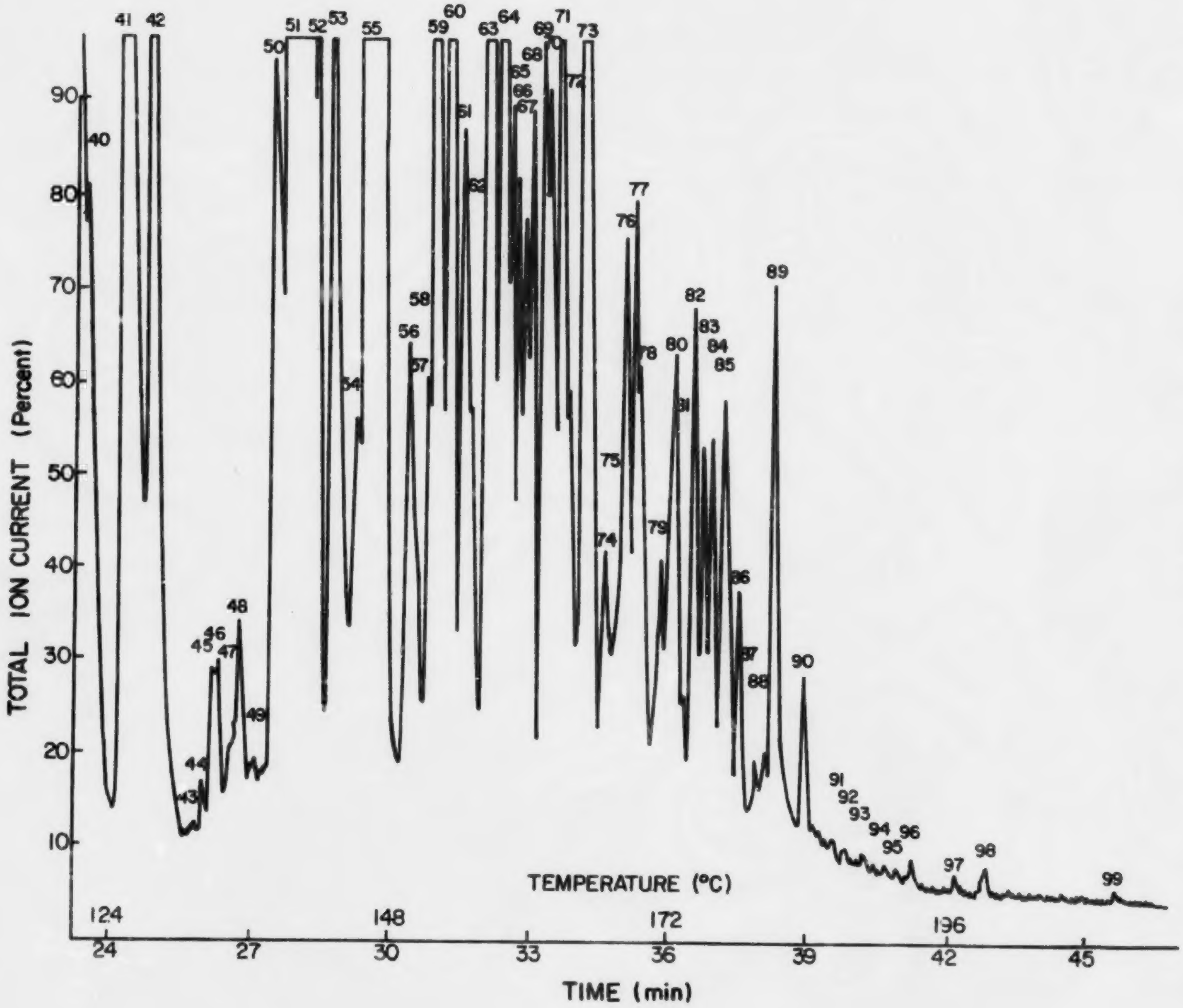

Figure 18 (cont'd)

Table 32. POLLUTANTS IDENTIFIED IN AMBIENT AIR FROM SANTA MONICA, CA[a]

Chromatographic Peak No.	Compound	Chromatographic Peak No.	Compound
1	air (O_2, CO_2)	31	C_8H_{18} (branched)
4	trichlorofluoromethane	32	C_6H_{16} (alkene, branched)
5	2-methylbutane	38	toluene
6	methylene chloride + C_5H_{10} (alkene)	39	3-methylheptane +
	acetone +		trimethylpentane isomer
7	dimethylbutane +	40	*n*-octane
	methylpentane isomer	41	tetrachloroethylene
8	hexane	42	dimethylheptane
10	C_6H_{12} (alkene)	43	methyloctane isomer
11	chloroform	44	trimethylcyclopentane isomer
14	1,2-dichloroethane	45	trimethylhexane isomer
15	methyl ethyl ketone	46	chlorobenzene
17	benzene	49	ethylbenzene
18	dimethylpentane isomer	50	*p*-xylene
19	2-methyl-1-hexane	51	*m*-xylene
20	3-methylhexane	53	dimethylheptane isomer
22	dimethylcyclopentane isomer	54	*o*-xylene
25	*n*-heptane	58	*n*-nonane
26	C_7H_{14} (cyclic, branched)	59	$C_{10}H_{22}$ (branched)
30	dimethylpentene isomer		

Table 32 (cont'd)

Chromatographic Peak No.	Compound	Chromatographic Peak No.	Compound
60	$C_{10}H_{22}$ (branched)	77	$C_{10}H_{20}$ (branched)
61	methylethylbenzene isomer	78	C_3-alkyl benzene
62	$C_{10}H_{22}$ (branched)	79	n-decane
63	$C_{10}H_{22}$ (branched)	80	$C_{10}H_{20}$ (branched)
64	$C_{10}H_{16}$ (ocimene-tent.)	81	dichlorobenzene isomer
65	$C_{10}H_{22}$ (branched)	82	$C_{11}H_{24}$ (branched)
66	$C_{10}H_{20}$ (branched)	83	$C_{11}H_{24}$ (branched)
67	β-pinene	84	trimethylbenzene isomer
68	isopropylheptane isomer	85	methylstyrene isomer
69	$C_{10}H_{20}$ (branched)	86	$C_{10}H_{30}$ (branched)
70	isopropylbenzene	87	diethylbenzene isomer
71	methylethylbenzene isomer	88	C_4-alkyl benzene
72	$C_{10}H_{22}$ (branched)	89	$C_{11}H_{24}$ (branched)
73	methylethylbenzene isomer	90	C_4-alkyl benzenes (4 peaks)
74	methylnonane isomer	99	C_5-alkyl benzenes (5 peaks)
75	n-propylbenzene isomer	100	$C_{12}H_{26}$

[a] See previous Figure.

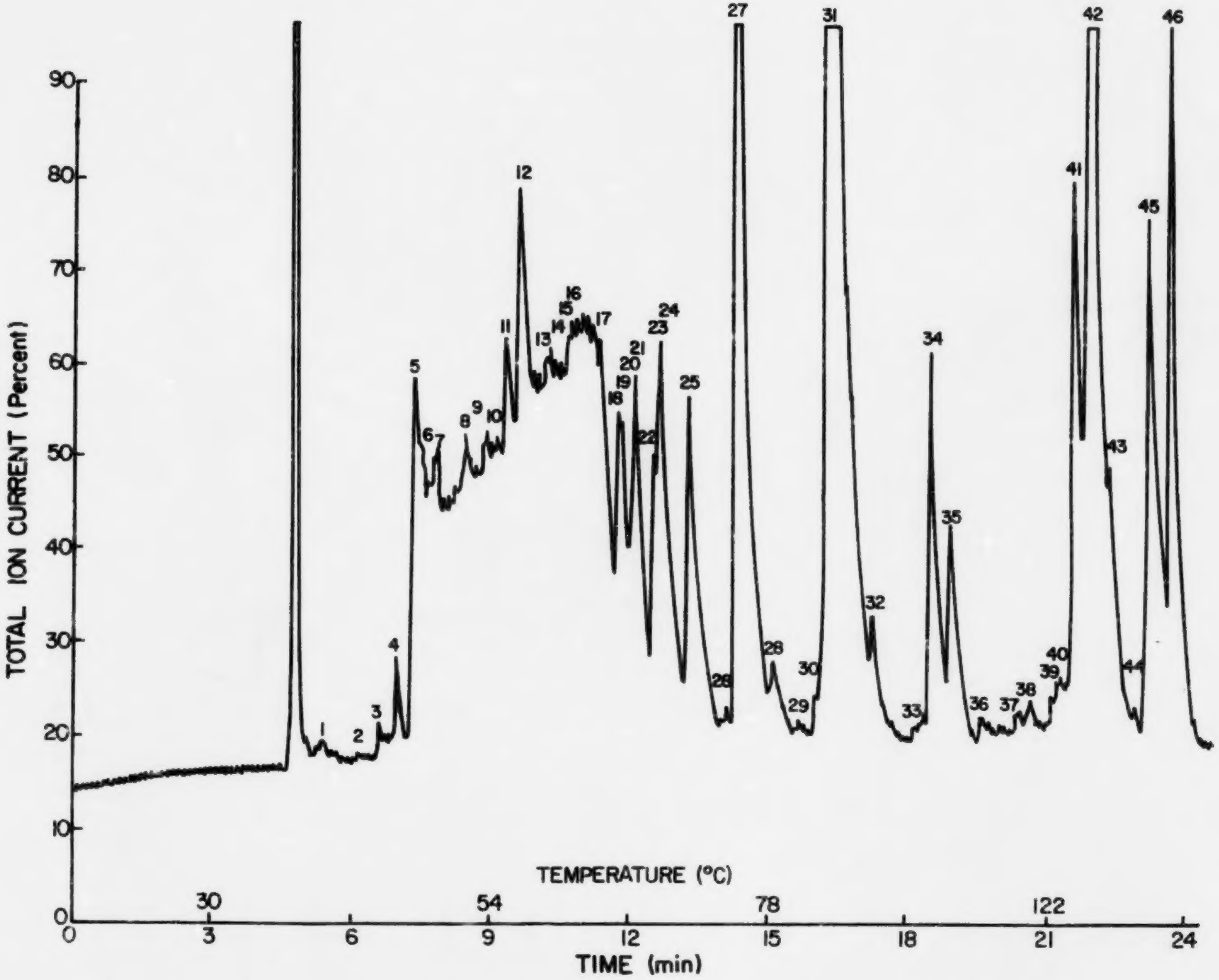

Figure 19. Total ion current plot during gas-liquid chromatography mass spectrometry of air sample from West Covina, CA. A 200 ft OV-17 SCOT was used, see text for conditions.

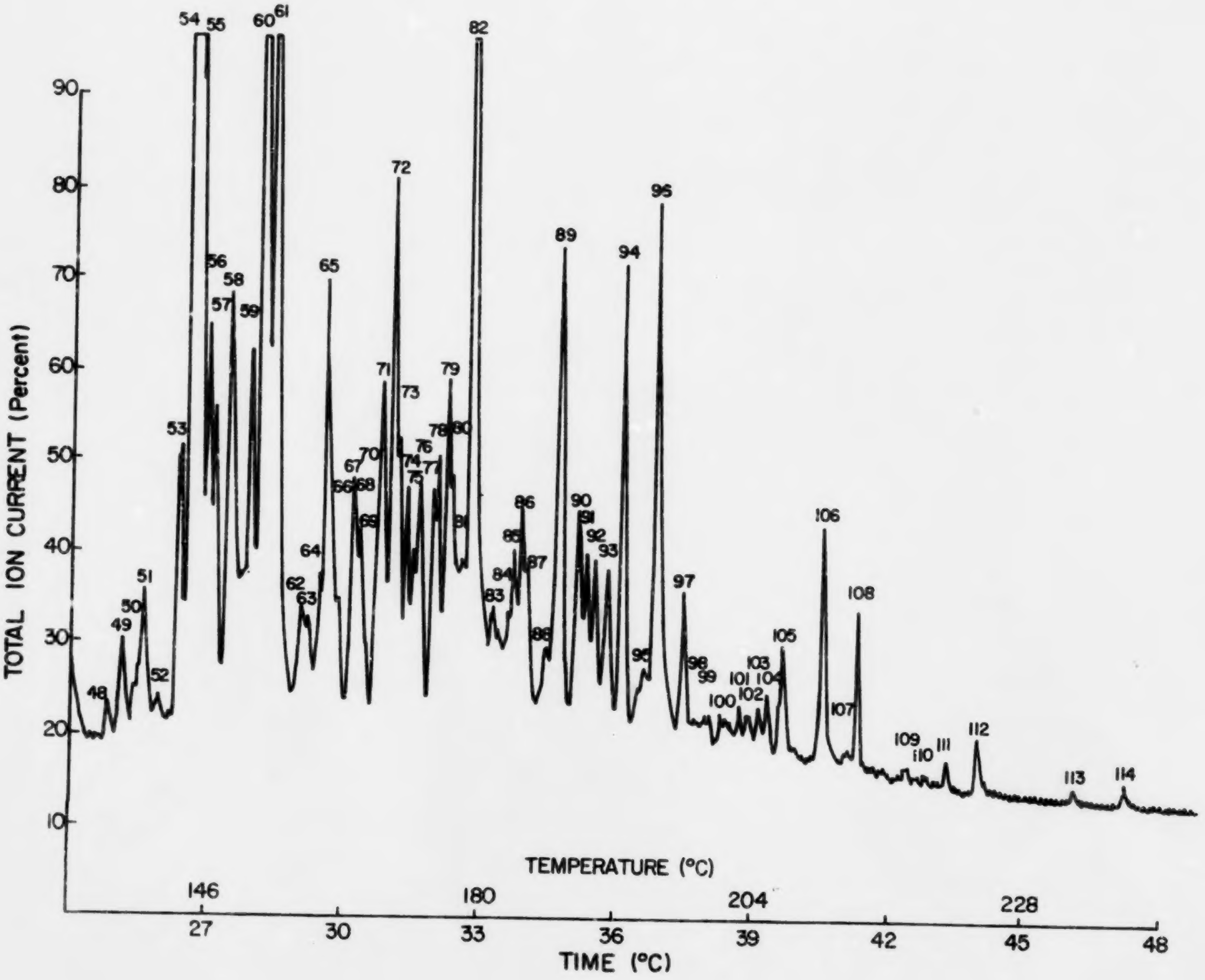

Figure 19 (cont'd)

Table 33. POLLUTANTS IDENTIFIED IN AMBIENT AIR FROM WEST COVINA, CA[a]

Chromatographic Peak No.	Compound	Chromatographic Peak No.	Compound
1	butane	23	dimethylcyclopentane (isomer ?)
2	butene isomer	24	trichloroethylene
3	trichlorofluoromethane	25	*n*-heptane
4	isopentane	26	C_7H_{12} isomer
5	methylene chloride	27	dimethylpentene (isomer ?)
6	2-methyl-2-butene	28	C_8H_{18} (branched alkane)
7	acetone	29	C_8H_{16}
8	$C_{16}H_{14}$	30	C_8H_{16}
9	C_6H_{14}	31	toluene
10	4-methyl-1-pentane	32	methylheptane isomer
11	*n*-hexane	33	C_8H_{14}
12	chloroform	34	*n*-octane
13	methylcyclopentane	35	tetrachloroethylene
14	methyl ethyl ketone	36	unknown
15	1,1,1-trichloroethane	37	C_9H_{20}
16	benzene	38	trimethylcyclopentane isomer
17	carbon tetrachloride	39	chlorobenzene
18	C_6H_{12}	40	C_9H_{18}
19	dimethylpentane (isomer ?)	41	ethylbenzene
20	dimethylcyclopentane (isomer ?)	42	*p*-xylene
21	3-methylhexane	43	*m*-xylene
22	dimethylcyclopentane (isomer ?)	44	2,4,4-trimethylhexane

Table 33 (cont'd)

Chromatographic Peak No.	Compound	Chromatographic Peak No.	Compound
45	*o*-xylene	67	methylstyrene isomer
46	*n*-nonane	68	$C_{10}H_{20}$
47	3,5,5-trimethylhex-1-ene	69	*o*-dichlorobenzene
48	C_9H_{18}	70	*p*-diethylbenzene
49	isopropylbenzene	71	*o*-propyltoluene
50	$C_{10}H_{20}$	72	dimethylethylbenzene (isomer ?)
51	C_9H_{18}	73	$C_{11}H_{24}$
52	$C_{10}H_{20}$	74	$C_{11}H_{24}$
53	*n*-propylbenzene	75	C_4-alkyl benzene
54	*m*-ethyltoluene	76	$C_{11}H_{24}$
55	*p*-ethyltoluene	77	C_4-alkyl benzene
56	$C_{10}H_{22}$	78	C_4-alkyl benzene
57	acetophenone	79	C_4-alkyl benzene
58	1,3,5-trimethylbenzene	80	1-phenyl-2-butene
59	benzaldehyde	81	C_4-alkyl benzene
60	1,2,4-trimethylbenzene	82	*n*-undecane
61	*n*-decane	83	C_4-alkyl benzene
62	isobutylbenzene	84	C_5-alkyl benzene
63	*m*-dichlorobenzene	85,86	C_4-alkyl benzene
64	C_4-alkyl benzene	87	$C_{12}H_{26}$
65	1,2,3-trimethylbenzene	88	C_5-alkyl benzene
66	$C_{11}H_{24}$		

Table 33 (cont'd)

Chromatographic Peak No.	Compound	Chromatographic Peak No.	Compound
89	ethylstyrene isomer	102	C_6-alkyl benzene
90	C_5-alkyl benzene	103	trichlorobenzene isomer
91	C_4-alkyl + C_5-alkyl benzenes	104,105	C_6-alkyl benzenes
92,93	C_5-alkyl benzenes	106	n-tridecane
94	unknown	107	methylnaphthalene isomer
95	trichlorobenzene isomer	108	unknown
96	naphthalene + n-dodecane	109	$C_{13}H_{26}$
97	$C_{13}H_{28}$	110	unknown
98,99	C_5-alkyl benzenes	111	unknown
100	$C_{13}H_{26}$	112	$C_{14}H_{30}$
101	C_5-alkyl + C_6-alkyl benzenes	113	unknown
		114	unknown

[a] See previous Figure.

Table 34. POLLUTANTS IDENTIFIED IN NIGHT AMBIENT AIR FROM WEST COVINA, CA[a]

Chromatographic Peak No.	Compound	Chromatographic Peak No.	Compound
1	carbon dioxide	17	3,3-dimethyl-1-pentene
2	methylcyclopropane (tent.)	18	1,1-dimethylcyclopentane
3	n-pentane	19	trichloroethylene
4	2-methyl-2-butene	20	n-heptane
5	methylene chloride	20A	5-methyl-2-hexene
6	2-pentene	21	1,1,2-2-tetramethylcyclopropane
6A	2,3-dimethylpentane	22	2,5-dimethylhexene
7	acetone	23	2,5-dimethyl-3-hexene
8	3-methylpentane	24	toluene
9	methylethylcyclopropane	25	2-methylheptane
10	n-hexane	26	3-methylheptane
10A	3-methylpentene	26A	2,3,4-trimethyl-2-pentene
11	1-hexene	27	unknown
12	methylcyclopentane	28	2,4-dimethylhexane
13	1,1,1-trichloroethane	29	n-octane
13A	3-methylcyclopentene	30	tetrachloroethylene
14	benzene	31	hexamethylcyclotrisiloxane
14A	carbon tetrachloride	32	1,2-dimethylcyclohexene
15	2-methylhexane	33	2,2,3,3-tetramethylpentane
16	3-methylhexane	34	unknown

Table 34 (cont'd)

Chromatographic Peak No.	Compound	Chromatographic Peak No.	Compound
35	chlorobenzene	56	1,2,4-trimethylbenzene
36	ethylbenzene + 4-methyloctane	57	2,6-dimethyloctane
37	*p*-xylene	58	*m*-dichlorobenzene
38	*m*-xylene	59	unknown
39	3-methyloctane	60	unknown
40	*o*-xylene	61	1,2,3-trimethylbenzene
41	unknown	62	unknown
42	4-ethylheptane	63	β-methylstyrene or indan (?)
43	unknown	64	unknown
44	2,2,3,3-tetramethylhexane	65	unknown
45	2,5-dimethyloctane	66	*o*-diethylbenzene
46	unknown	67	*p*-diethylbenzene
47	unknown	68	unknown
48	unknown	69	unknown
48A	*n*-propylbenzene	70	unknown
49	*m*-ethyltoluene	71	unknown
50	C_3-alkyl benzene	72	1,4-dimethyl-2-ethylbenzene
51	unknown	73	1,3-dimethyl-4-ethylbenzene
52	C_3-alkyl benzene	74	1,2-dimethyl-4-ethylbenzene
53	*o*-ethyltoluene	75	*n*-undecane
54	unknown	76	5-methyldecane (tent.)
55	octamethylcyclotetrasiloxane	77	1,2-dimethyl-3-ethylbenzene

Table 34 (cont'd)

Chromatographic Peak No.	Compound	Chromatographic Peak No.	Compound
78	(1-methylbutyl)benzene (tent.)	86	1,2,4,5-tetramethylbenzene
79	*n*-dodecane	87	unknown
80	1,3-dimethyl-2-ethylbenzene	88	unknown
81	2-methyldecalin (tent.)	89	tetradecamethylhexasiloxane
82	decamethylcyclopentasiloxane	90	unknown
83	1-phenyl-2-butene (tent.)	91	unknown
84	2-phenyl-2-methylbutane	92	2-methyl-3-heptanone (tent.)
85	(2-methylpropenyl)benzene	92A	1-methyl-3-*t*-butylbenzene (tent.)

[a] A 200 ft OV-101 SCOT programmed from 30-220°C @ 4°/min was used.

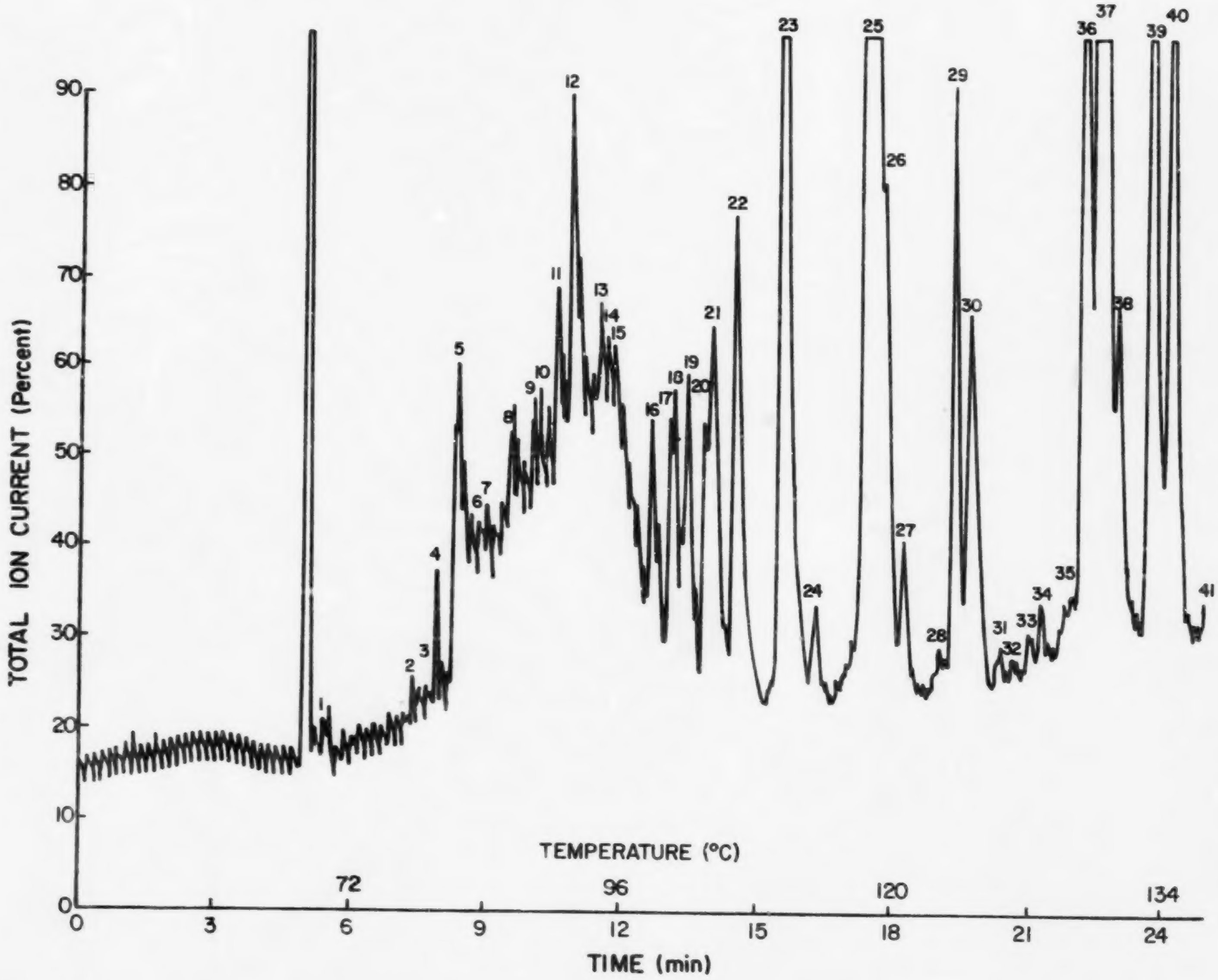

Figure 20. Total ion current plot during gas-liquid chromatography mass spectrometry of air sample from Glendora, CA. A 200 ft OV-17 SCOT was used, see text for conditions.

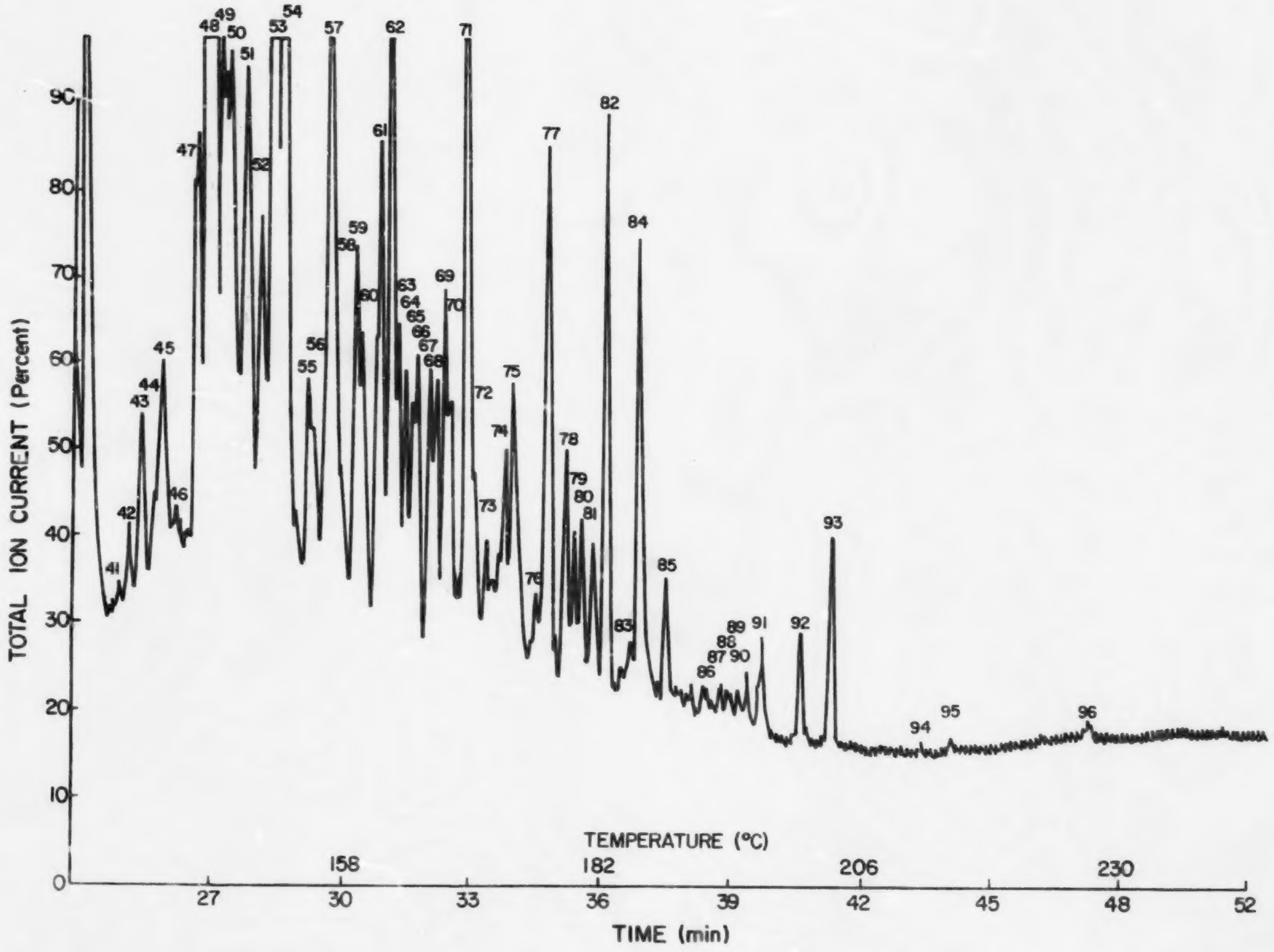

Figure 20 (cont'd)

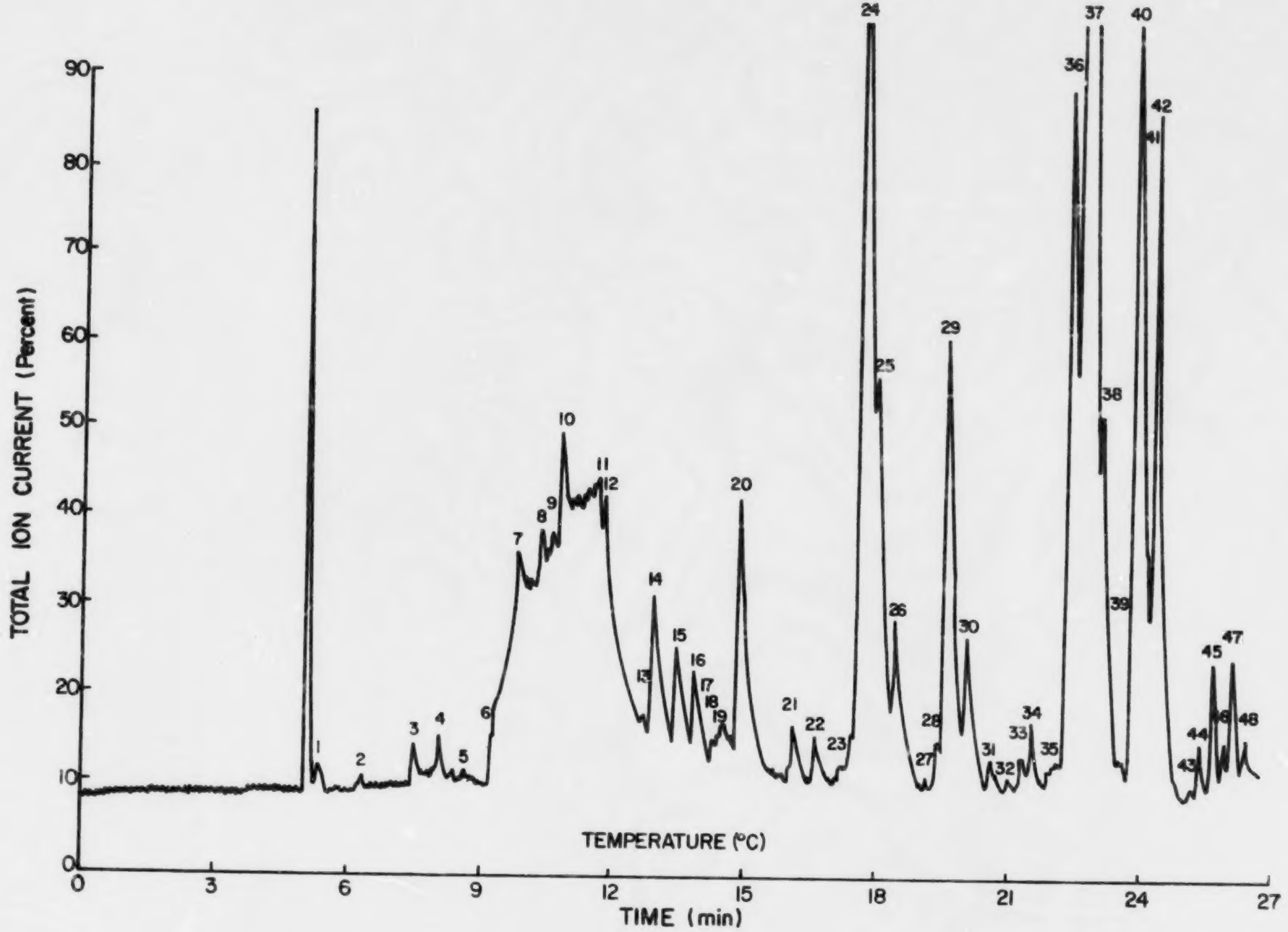

Figure 21. Total ion current plot during gas-liquid chromatography mass spectrometry of air sample from Anaheim, CA. A 200 ft OV-101 SCOT was used, see text for conditions.

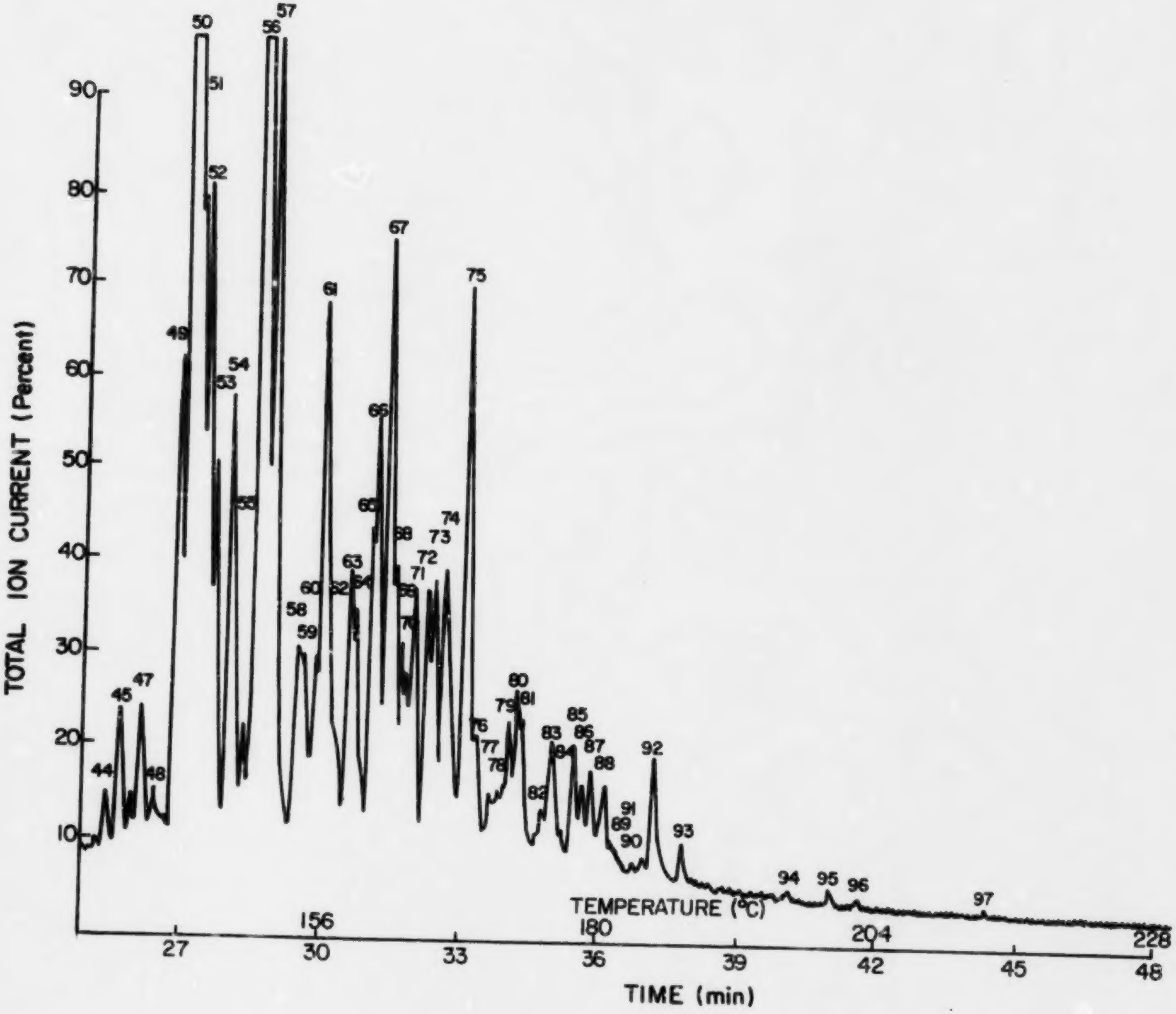

Figure 21 (cont'd)

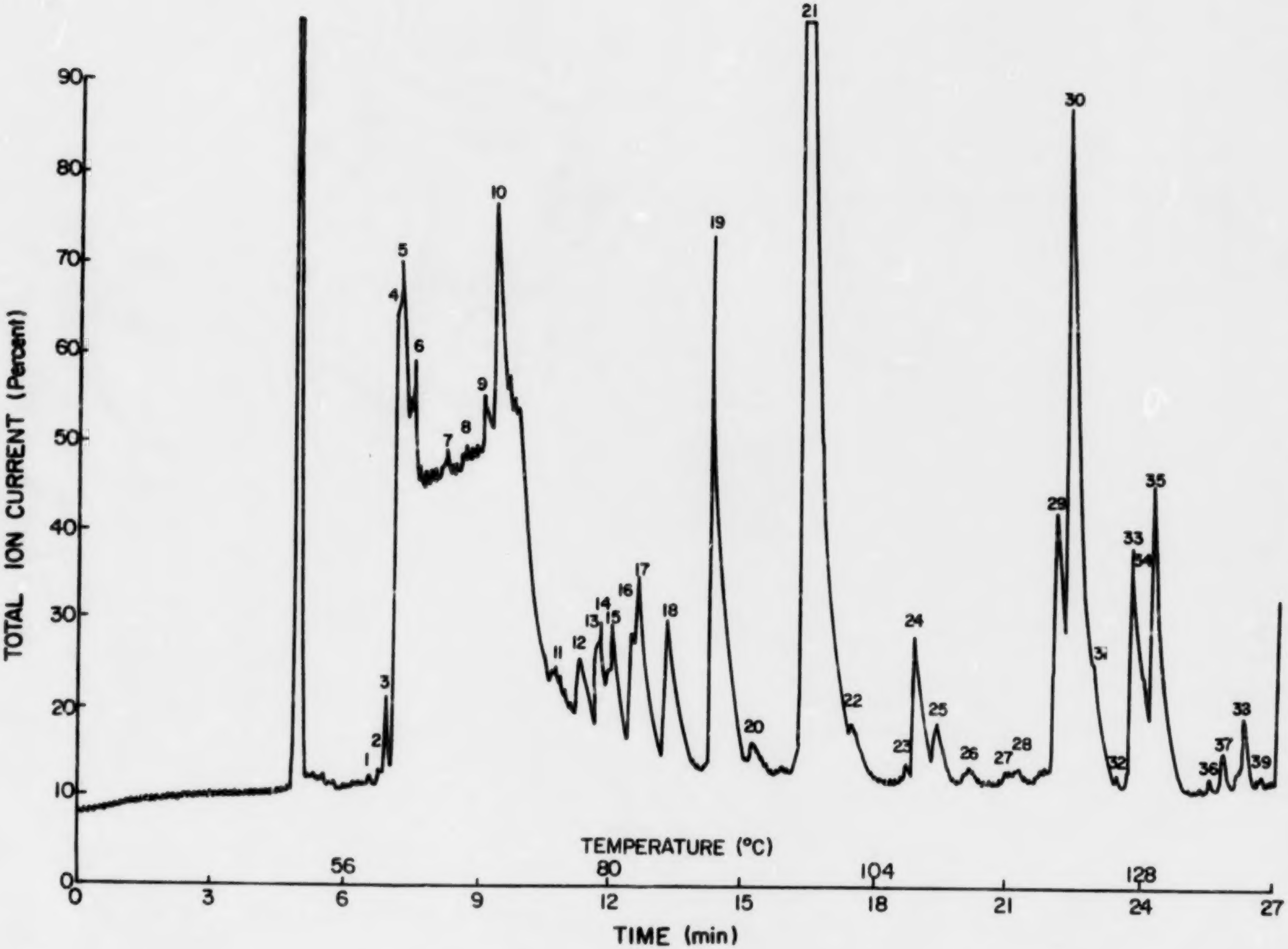

Figure 22. Total ion current plot during gas-liquid chromatography mass spectrometry of night air sample from Anaheim, CA. A 200 ft OV-101 SCOT was used, see text for conditions.

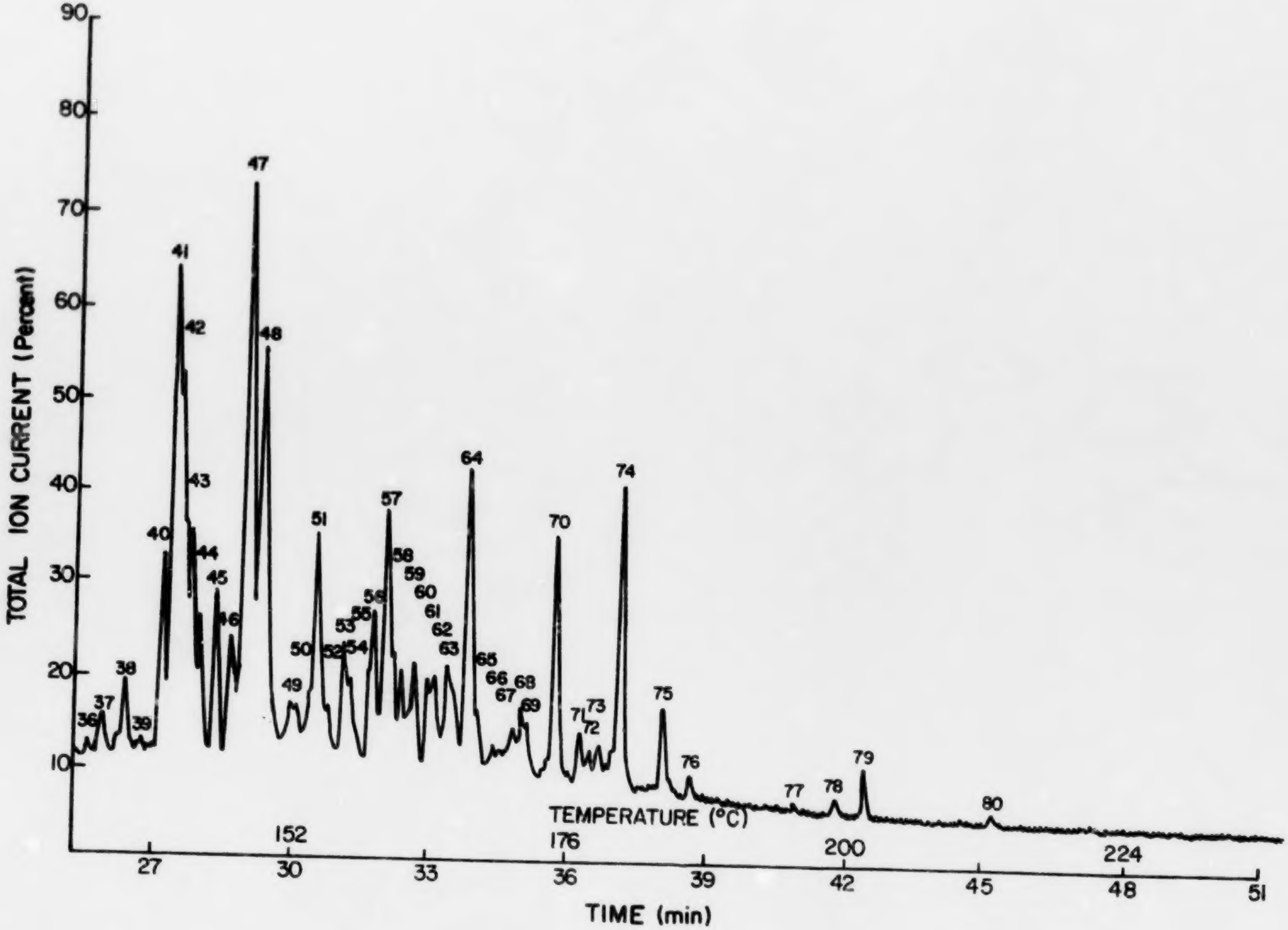

Figure 22 (cont'd)

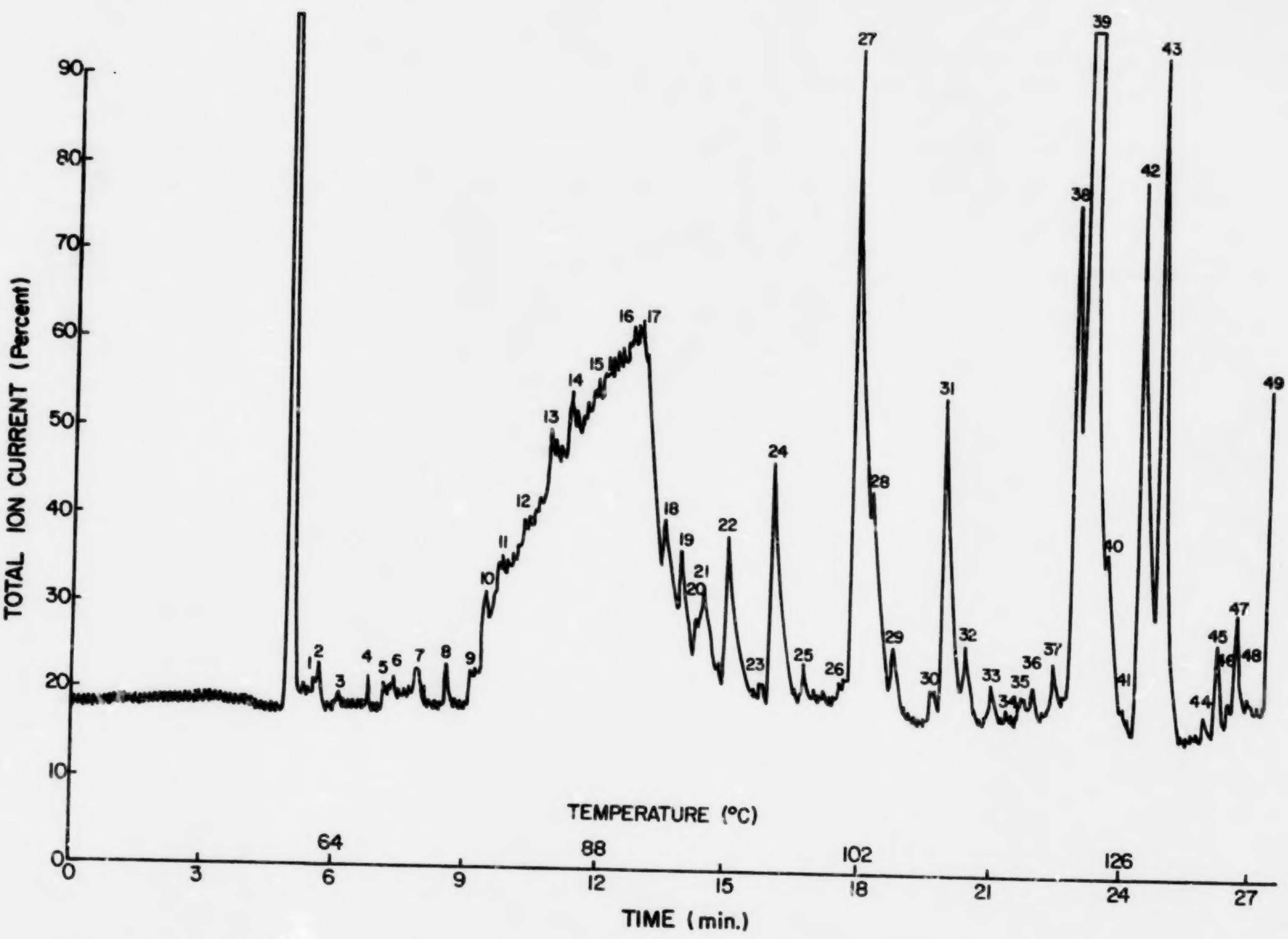

Figure 23. Total ion current plot during gas-liquid chromatography mass spectrometry of air samples from Garden Grove, CA. A 200 ft OV-101 SCOT was used, see text for conditions.

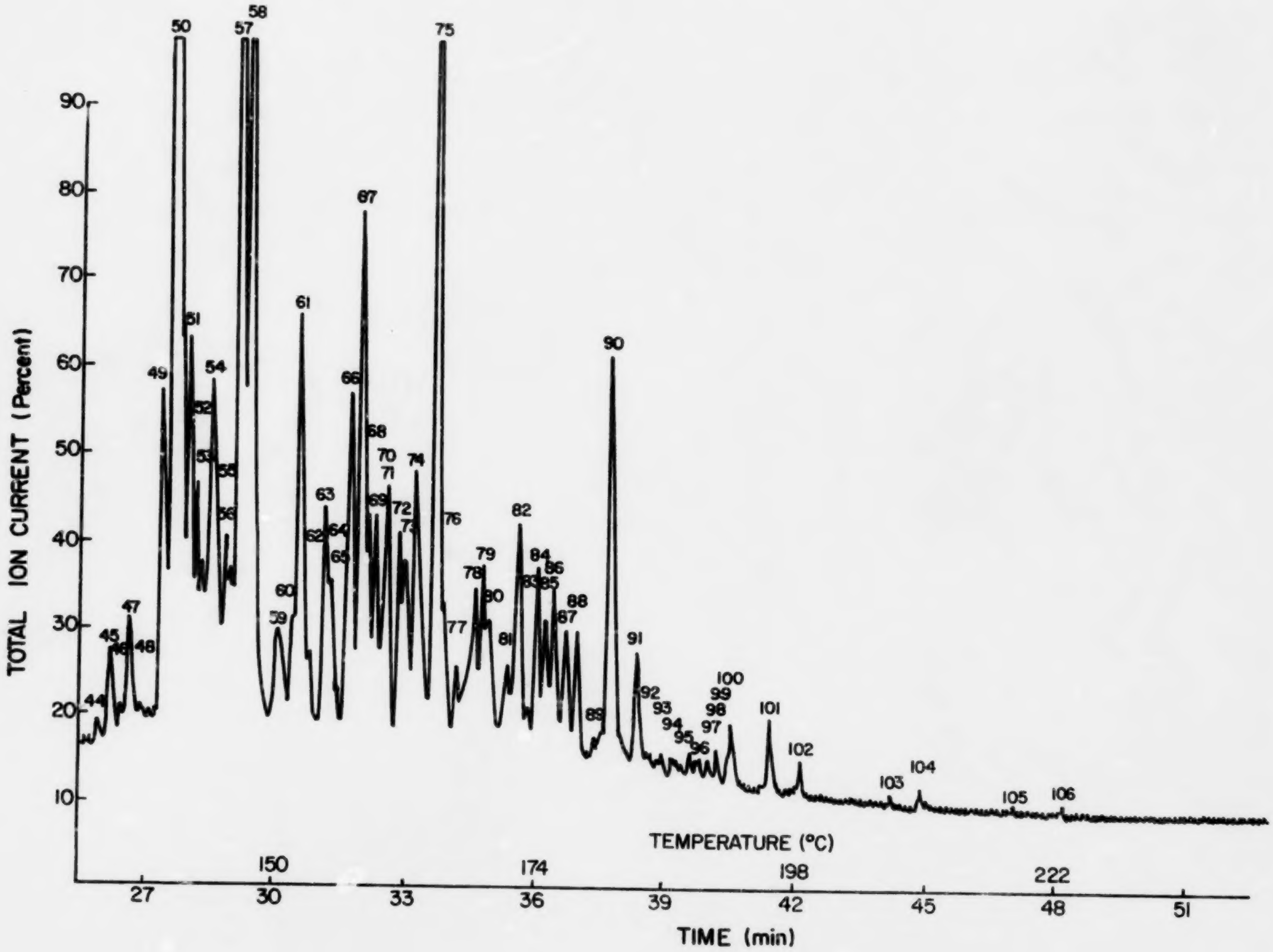

Figure 23 (cont'd)

Table 35. POLLUTANTS IDENTIFIED IN AMBIENT AIR FROM SANTA MONICA, CA[a]

Chromatographic Peak No.	Compound
1	n-butane
2	2-butene
3	isopentane
4	n-pentane + trichlorofluoromethane
5	2-pentyne
6	2,3-dimethylbutane
7	3-methylpentane
8	n-hexane
9	methylene chloride
10	diethyl ether
11	acetone
12	methylcyclopentane
13	C_7H_{16}
14	2,3 dimethylpentane
15	3-methylhexane
16	dimethylcyclopentane (isomer ?)
17	n-heptane + chloroform
18	1,1,1-trichloroethane
19	carbon tetrachloride
20	C_8H_{16}
21	dimethylhexane (isomer ?)
22	benzene
23	dimethylpentane (isomer ?)
24	C_7H_{14}
25	2,5-dimethylhexane
26	2,3,3-trimethylpentane
27	3-methylheptane
28	n-octane
29,30	C_8H_{16} (isomers)
31-33	C_9H_{20} (isomers)

Table 35 (cont'd)

Chromatographic Peak No.	Compound
34	toluene
34-37	C_9H_{20} (isomers)
38	tetrachloroethylene
39	C_9H_{18}
40	n-octane
41	C_9H_{18}
42-46	$C_{10}H_{22}$ (isomers)
47	ethylbenzene
48	p-xylene + m-xylene
49	2,6-dimethyloctane
50,51	$C_{10}H_{22}$ (isomers)
52	o-xylene
53	phenylacetylene
54	n-decane + styrene
55	isopropylbenzene
56-60	$C_{11}H_{24}$ (isomers)
61	n-propylbenzene
62	m-ethyltoluene
63	p-ethyltoluene
64-66	$C_{11}H_{24}$ (isomers)
67	o-ethyltoluene
68	$C_{11}H_{24}$
69	1,2,4-trimethylbenzene
70	n-undecane
71	o-cymene
72-75	$C_{11}H_{22}$ (isomers)
76	1,2,3 trimethylbenzene
77	sec-butylbenzene
78	isobutylbenzene + dichlorobenzene (isomer)
79	C_4-alkyl benzene
80	methylstyrene (isomer ?)

Table 35 (cont'd)

Chromatographic Peak No.	Compound
81,82	C_4-alkyl benzenes
83	$C_{11}H_{22}$
84-86	C_4-alkyl benzenes
87	C_5-alkyl benzene
88	C_4-alkyl benzene
89	*n*-dodecane
90	ethylstyrene (isomer)
91-94	C_4-alkyl benzenes
94-100	C_5-alkyl benzenes
101	ethylstyrene (isomer)
102	tetramethylbenzene (isomer ?)
103	C_5-alkyl benzene
104	ethylstyrene (isomer)
105	C_5-alkyl benzene
106	naphthalene
107	2,6-ditertiarybutyl-*p*-cresol

[a] Resolution was achieved on a 200 ft OV-17 SCOT column, programmed from 30-220°C @ 4°/min.

Table 36. POLLUTANTS IDENTIFIED IN AMBIENT AIR FROM WEST COVINA, CA[a]

Chromatographic Peak No.	Compound
1	_n_-butane
2	isopentane
3	_n_-pentane + trichlorofluoromethane
4	2,3-dimethylbutane
5	3-methylpentane
6	_n_-hexane
7	methylene chloride
8	acetone
9	methylcyclopentane
10	2,2,3-trimethylbutane
11	2,3-dimethylpentane
12	3-ethylpentane
13	3-methylhexane
14	dimethylpentene (isomer ?)
15	dimethylcyclopentane (isomer ?)
16	chloroform + _n_-heptane
17	dimethylcyclopentane (isomer ?)
18	dimethylhexane (isomer ?)
19	benzene
20	dimethylpentane (isomer)
21,22	C_8H_{18} (isomers)
23	_n_-octane
24	siloxane isomer
25,26	C_9H_{20} (isomers)
27	toluene
28,29	C_9H_{20} (isomers)
30	tetrachloroethylene
31	C_9H_{20}
32	_n_-nonane
33	C_9H_{18}

Table 36 (cont'd)

Chromatographic Peak No.	Compound
34-36	$C_{10}H_{22}$ (isomers)
37	ethylbenzene
38	p-xylene
39	m-xylene
40-2	$C_{10}H_{22}$ (isomers)
43	o-xylene
44	$C_{11}H_{24}$
45	n-decane
46-48	$C_{11}H_{24}$
49,50	$C_{10}H_{20}$
51	n-propylbenzene
52	m-ethyltoluene
53	p-ethyltoluene
54,55	$C_{11}H_{24}$ (isomers)
56	o-ethyltoluene
57	$C_{11}H_{24}$
58	1,2,4-trimethylbenzene
59	n-undecane
60	o-cymene
61	$C_{12}H_{26}$
62	$C_{11}H_{22}$
63	1,2,3-trimethylbenzene
64	dichlorobenzene (isomer) + C_4-alkyl benzene
65	C_4-alkyl benzene
66	methylstyrene isomer
67-70	C_4-alkyl benzenes
71	n-dodecane
72	ethylstyrene isomer
73-75	C_4-alkyl benzenes
76-84	C_5-alkyl benzenes
85	ethylstyrene isomer

Table 36 (cont'd)

Chromatographic Peak No.	Compound
86-88	C_5-alkyl benzenes
89	C_6-alkyl benzene
90	C_5-alkyl benzene
90A	trichlorobenzene isomer
91	naphthalene
92	$C_{13}H_{28}$
93,94	$C_{14}H_{30}$

[a] Resolution was on a 200 ft OV-17 SCOT programmed from 30-220° @ 4°/min.

Table 37. POLLUTANTS IDENTIFIED IN AMBIENT AIR FROM GLENDORA, CA[a]

Chromatographic Peak No.	Compound
1	n-butane
2	2-butene
3	unknown
4	isopentane
5	n-pentane + trichlorofluoromethane
6	unknown
7	unknown
8	2-methylpentane
9	3-methylpentane
10	n-hexane
11	methyl n-propyl ether + methylene chloride
12	acetone
13	methylcyclopentane
14,15	C_7H_{16} (isomers)
16	2,3-dimethylpentane
17	3-methylhexane
18	dimethylcyclopentane (isomer)
19	n-heptane
20	chloroform
21	1,1,1-trichloroethane + carbon tetrachloride
22	C_8H_{18}
23	C_8H_{16}
24	benzene
25	dimethylpentene (isomer ?)
26	C_7H_{14}
27	C_8H_{18}
28	trichloroethylene + C_8H_{18}
29	n-octane
30	C_8H_{16}
31,32	C_9H_{20}

Table 37 (cont'd)

Chromatographic Peak No.	Compound
33	toluene
34	2,3-dimethylheptane
35-37	C_9H_{20} (isomers)
38	tetrachloroethylene
39	C_9H_{18}
40	n-nonane
41	C_9H_{18} + $C_{10}H_{22}$
42-47	$C_{10}H_{22}$ (isomers)
48	ethylbenzene
49	p-xylene
50	m-xylene
51-3	$C_{10}H_{22}$ (isomers)
54	o-xylene
55	$C_{11}H_{24}$
56	n-decane
57-61	$C_{11}H_{24}$ (isomers)
62	bromoform + $C_{11}H_{24}$
63	n-propylbenzene
64	m-ethyltoluene
65	p-ethyltoluene
66	$C_{11}H_{24}$
67	$C_{10}H_{20}$
68	$C_{11}H_{24}$
69	o-ethyltoluene
70	$C_{11}H_{22}$
71	1,2,4-trimethylbenzene
72	n-undecane
73	C_4-alkyl benzene
74,75	$C_{11}H_{22}$ (isomers)
76	cyclopentylcyclopentane (tent.)
77	1,2,3-trimethylbenzene

Table 37 (cont'd)

Chromatographic Peak No.	Compound
78	isobutylbenzene + benzaldehyde
79	m-dichlorobenzene
80,81	C_4-alkyl benzenes
82	$C_{12}H_{26}$
83	methylstyrene isomer
84	C_4-alkyl benzene
85	$C_{11}H_{22}$
86	C_4-alkyl benzene
87	o-dichlorobenzene + C_4-alkyl benzene
88	C_4-alkyl benzene
89	C_5-alkyl benzene + ethylstyrene
90	n-dodecane
91	C_5-alkyl benzene
92,93	C_4-alkyl benzenes
94-98	C_5-alkyl benzenes
99	$C_{13}H_{26}$
100	C_5-alkyl benzene
101	acetophenone
102-104	C_5-alkyl benzenes
105	ethylstyrene isomer
106	$C_{14}H_{30}$
107	C_5-alkyl benzene + $C_{11}H_{14}$
108	C_6-alkyl benzene
109	C_5-alkyl benzene + $C_{11}H_{14}$
110	naphthalene
111	C_5-alkyl benzene
112	$C_{14}H_{30}$

[a] Resolution was on a 200 ft OV-17 SCOT programmed from 30-220°C @ 4°/min.

Table 38. POLLUTANTS IDENTIFIED IN AMBIENT AIR FROM GARDEN GROVE, CA[a]

Chromatographic Peak No.	Elution Temperature (°C)	Compound
1	48	n-butane
2	52	unknown
3	53	isopentane
4	56	unknown
5	57	2,3-dimethylbutane
6	59	n-hexane
7	60	methylene chloride
8	61	methyl isopropyl ether
9	63	acetone
10	67	C_7H_{16}
11	68	2,3-dimethylpentane
12	68	3-methylhexane
13	70	C_7H_{16}
14	71	chloroform
15	72	dimethylcyclopentane (isomer ?)
16	72	dimethylcyclopentane (isomer ?)
17	73	1,1,1-trichloroethane
18	76	C_8H_{18}
19	77	benzene
20	78	dimethylpentene (isomer ?)
21	83	C_8H_{18}
22	85	3-methylheptane
23	89	n-octane
24	93	hexamethylcyclotrisiloxane
25	96	C_8H_{16}
26	98	toluene
27,28	102	C_9H_{20} (isomers)
29	104	tetrachloroethylene
30	108	n-nonane

Table 38 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
31	112	C_9H_{18}
32-34	113,115,116	$C_{10}H_{22}$ (isomers)
35	117	ethylbenzene
36	118	p-xylene
37-39	119,121,122	$C_{10}H_{22}$ (isomers)
40	124	o-xylene
41	125	phenylacetylene
42	126	n-decane
43	128	isopropylbenzene
44	129	$C_{10}H_{20}$
45-48	130,131,132,133	$C_{11}H_{24}$ (isomers)
49	134	n-propylbenzene
50	135	m-ethyltoluene
51	136	p-ethyltoluene
52-54	137,138,139	$C_{11}H_{24}$ (isomers)
55	140	o-ethyltoluene
56	141	unknown
57	142	1,2,4-trimethylbenzene
58	143	n-undecane
59	144	unknown
60	146	C_4-alkyl benzene
61	148	$C_{11}H_{22}$
62	149	1,2,3-trimethylbenzene
63	150	benzaldehyde
64	151	m-dichlorobenzene
65,6	152,153	C_4-alkyl benzenes
67	154	methylstyrene (isomer ?)
68	155	C_4-alkyl benzene
69	156	o-dichlorobenzene + C_4-alkyl benzene
70	157	C_4-alkyl benzene

Table 38 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
71	158	C_5-alkyl benzene
72	159	ethylstyrene (isomer ?)
73	160	$C_{12}H_{26}$
74	161	C_5-alkyl benzene
75	163	C_4-alkyl benzene
76	164	C_5-alkyl benzene
77	165	C_4-alkyl benzene
78-83	166,167,168,169, 170	C_5-alkyl benzenes
84	171	tolualdehyde
85	172	C_5-alkyl benzenes
86	173	ethylstyrene (isomer ?)
87	175	C_5-alkyl benzene
88	177	$C_{13}H_{28}$
89	178	trichlorobenzene (isomer)

[a] Resolution was on a 200 ft OV-17 SCOT column programmed from 30-220°C @ 4°/min.

Table 39. POLLUTANTS IDENTIFIED IN AMBIENT AIR FROM ANAHEIM, CA[a]

Chromatographic Peak No.	Compound
1	*n*-butane
2	2-butene
3	isopentane
4	*n*-pentane + trichlorofluoromethane
5	unknown
6	furan
7	2,3-dimethylbutane
8	3-methylpentane
9	*n*-hexane
10	methylene chloride
11	methyl *n*-propyl ether
12	acetone
13	methylcyclopentane
14	C_7H_{16}
15	2,3-dimethylpentane
16	3-methylhexane
17	C_7H_{16}
18	chloroform
19,20	dimethylcyclopentanes
21	1,1,1-trichloroethane
22	carbon tetrachloride
23	C_8H_{18}
24	C_8H_{16}
25	benzene
26	dimethylpentene (isomer ?)
27	3-methyl-1-hexene
28	C_7H_{12} + C_8H_{18}
29	dimethylfuran (isomer ?)
30	*n*-octane
31	hexamethylcyclotrisiloxane

Table 39 (cont'd)

Chromatographic Peak No.	Compound
32	C_9H_{20}
33	toluene
34,35	C_9H_{20} (isomers)
36	tetrachloroethylene
37	_n_-nonane
38	C_9H_{18}
39-42	$C_{10}H_{22}$ (isomers)
43	ethylbenzene
44	_p_-xylene
45,46	$C_{10}H_{22}$ (isomers)
47	_o_-xylene
48	phenylacetylene
49	_n_-decane
50	$C_{10}H_{20}$
51	isopropylbenzene
52-55	$C_{11}H_{24}$ (isomers)
56	_n_-propylbenzene
57	_m_-ethyltoluene
58	_p_-ethyltoluene
59	$C_{11}H_{24}$
60	$C_{10}H_{20}$
61	$C_{11}H_{24}$
62	_o_-ethyltoluene
63	unknown
64	1,2,4-trimethylbenzene
65	_n_-undecane
66	C_4-alkyl benzene
67	$C_{11}H_{22}$
68	$C_{12}H_{26}$
69	$C_{11}H_{22}$
70	1,2,3-trimethylbenzene

Table 39 (cont'd)

Chromatographic Peak No.	Compound
71	benzaldehyde + m-dichlorobenzene + C_4-alkyl benzene
72,73	C_4-alkyl benzene
74	$C_{12}H_{26}$
75	methylstyrene isomer
76	C_4-alkyl benzene
77	$C_{11}H_{22}$
78	C_4-alkyl benzene
79	o-dichlorobenzene + C_4-alkyl benzene
80	C_4-alkyl benzene
81	C_5-alkyl benzene
82	$C_{12}H_{26}$
83	C_5-alkyl benzene
84	$C_{12}H_{24}$
85-87	C_4-alkyl benzene
88-91	C_5-alkyl benzenes
92	tolualdehyde isomer
93	C_5-alkyl benzene
94	acetophenone
95	ethylstyrene (isomer)
96	C_4-alkyl benzene
97	C_5-alkyl benzene
98	ethylstyrene isomer
99	$C_{13}H_{28}$
100	tetrahydronapthalene (isomer)
101,102	C_5-alkyl benzenes
103	trichlorobenzene isomer
104-106	C_6-alkyl benzenes
107	naphthalene

Table 39 (cont'd)

Chromatographic Peak No.	Compound
108	C_6-alkyl benzene
109	$C_{14}H_{30}$

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[a] Resolution was on a 200 ft OV-17 SCOT programmed from 30-220°C @ 4°/min

Table 40. POLLUTANTS IDENTIFIED IN NIGHT AMBIENT AIR FROM SANTA MONICA, CA[a]

Chromatographic Peak No.	Elution Temperature (°C)	Compound
-	52	chlorodifluoromethane (Freon 22)
1	53	isobutane
2	55	n-butane + 1-butene
2A	56	sulfur dioxide
3	58	isopentane
3A	59	C_6H_{12}
4	60	trichlorofluoromethane (Freon 11)
4A	62	2-methylbutane
4B	63	furan
5	65	2-methylpentane
6	67	C_6H_{12}
7	68	n-hexane
8	70	methylene chloride
9	71	trans-3-hexene
10	-	unknown
11	-	unknown
12	73	methylcyclopentane
12A	74	acetone
13	76	acetylacetone
14	76.5	C_5H_{10}
15	77	2,3-dimethylpentane
16	79	chloroform
17	81	n-heptane
17A	82	C_7H_{14}
18	82.5	carbon tetrachloride
19	83	C_9H_{18}
20	85	C_7H_{14}
21	85	C_8H_{18}

Table 40 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
22	86	benzene
23,24	87,89	C_7H_{14} (isomers)
25	90	2,5-dimethylhexane
26	91	trichloroethylene
27	92.5	3-methylheptane
28	95	C_8H_{16}
29	97	3-methyl-3-ethylpentane
30	99	hexamethylcyclotrisiloxane
31	-	unknown
32	102	C_9H_{20}
33	103	3,3-diethylpentane
34	104	toluene
35	108	C_6H_{12}
36	108	3,3-dimethylheptane
37	109	C_9H_{20}
38	109	$C_{10}H_{22}$
39	110	tetrachloroethylene
40	114	_n_-nonane
40A,41	115,116.5	C_9H_{18}
41A,44	117,118,119.5,120	$C_{10}H_{22}$
45	-	unknown
46	-	unknown
47	122	ethylbenzene
48	123	_p_-xylene
49	124	$C_{10}H_{22}$
50	124.5	C_9H_{18}
51	126	C_8H_{16}
52	126	$C_{10}H_{16}$
53	128	_m_-xylene
54	130	phenylacetylene
55	131	2,6-dimethyloctane

Table 40 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
56	131.5	$C_{10}H_{20}$
57	132.5	isopropylbenzene
58	-	unknown
59	134	vinyl 2-ethylhexyl ether
60	135.5	$C_{11}H_{24}$
61	136	$C_{10}H_{20}$
62	-	unknown
63	137	$C_{11}H_{24}$
63A	137	bromoform
64	138	n-propylbenzene
65	139.5	m-ethyltoluene
66	140.5	p-ethyltoluene
67	142	$C_{10}H_{20}$
67A	142	$C_{11}H_{22}$
68	143	$C_{11}H_{24}$
69	143.5	o-ethyltoluene
70	-	unknown
71	146	1,3,5-trimethylbenzene
72	147.5	n-undecane
73	-	unknown
74	-	unknown
75	149	o-cymene
76	151	$C_{10}H_{18}$
77	152	$C_{11}H_{22}$
78	152.5	1,2,4-trimethylbenzene
79	154	sec-butylbenzene
80	154	m-dichlorobenzene
81	154.5	isopropylbenzene
82	155	1,2-dimethyl-2-ethylbenzene
83	-	unknown
84	156.5	o-methylstyrene

Table 40 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
85	157	1-methyl-2-*n*-propylbenzene
86	-	unknown
87	159	C_4-alkyl benzene
88	159.5	C_4-alkyl benzene
89	160.5	1,4-dimethyl-2-ethylbenzene
90	162	C_5-alkyl benzene
91	-	unknown
92	163.5	*n*-dodecane
93	164	*p*-ethylstyrene
94	165	$C_{12}H_{24}$
95	-	unknown
96	166.5	C_4-alkyl benzene
96A	166.5	C_4-alkyl benzene
97-99	168,169,169.5	C_5-alkyl benzene
100	-	unknown
101	171.5	(1-methylbutyl)benzene
102	172	*n*-tetradecane
103	172.5	C_5-alkyl benzene
104	173	4-methylindan
105	174	C_4-alkyl benzene
106	174.5	C_5-alkyl benzene
107	175.5	*p*-ethylstyrene
108,109,109A,110	178,179,179.5	C_5-alkyl benzenes
111	181	$C_{11}H_{20}$
111A	181	C_6-alkyl benzene
112	182	C_5-alkyl benzene
113	182	C_6-alkyl benzene
114	182	C_5-alkyl benzene
115	183.5	C_6-alkyl benzene
116	184.5	C_5-alkyl benzene

Table 40 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
117	186	C_6-alkyl benzene
118	187	naphthalene
118A,119	188,191	C_5-alkyl benzene

[a] Resolution was on a 200 ft OV-17 SCOT programmed from 30-220 @ 4°/min.

Table 41. POLLUTANTS IDENTIFIED IN NIGHT AMBIENT AIR FROM ANAHEIM, CA[a]

Chromatographic Peak No.	Elution Temperature (°C)	Compound
1	-	unknown
2	54	1-butene
3	56.5	_n_-pentane
4	57	trichlorofluoromethane
4A	58	1-pentane
5	59.5	C_5H_{10}
5A	60	furan
6	61.5	2,3-dimethylbutane
7	63	3-methylpentane
8	64.5	_n_-hexane
9	-	unknown
10	65	methylene chloride
11	66	propanol (tent.) (isomer)
12	66.5	1-methyl-1-ethylcyclopropane
13	68	acetone
14	69	C_6H_{12}
15	-	unknown
16	71	acetylacetone
17	72	C_6H_{10}
18	73	_n_-heptane
19	74	chloroform
20	75	3,3-dimethylpentane
21	77	carbon tetrachloride
22	78	C_6H_{14}
23	79.5	C_9H_{14}
24	80	C_8H_{18}
25	81.5	benzene
26	83	dimethylpentene (isomer ?)
27	-	unknown
28	86	2,5-dimethylhexane

Table 41 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
29	87	trichloroethylene
30	88	3-methylheptane
31	-	unknown
32	91.5	3-methylheptene (isomer ?)
33	94.5	hexamethylcyclotrisiloxane
34	97.5	1-octene
35	98	C_9H_{20}
36	98.5	n-propyl acetate
37	101	toluene
38	103.5	C_9H_{20}
39	105	C_7H_{16}
40	106	tetrachloroethylene
41	110	4-ethylheptane
42	113.5	1-methyl-cis-2-ethylcyclohexane
43	115.5	2,6-dimethyloctane
44	117	$C_{10}H_{22}$
45	118	C_9H_{18}
46	-	unknown
47	119	ethylbenzene
48	120.5	p-xylene
49	121	C_9H_{18}
50	121.5	$C_{10}H_{22}$
51	124	C_8H_{16}
52	126.5	m-xylene
53	127	phenylacetylene
54	128.5	styrene
55	130.5	isopropylbenzene
56	131	$C_{11}H_{24}$
57	132	4-methyldecane
58	-	unknown

Table 41 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
59	133.5	$C_{10}H_{20}$
60	135	vinyl-2-ethylhexyl ether (tent.)
60A	135	bromoform
61	136	n-propylbenzene
62	138.5	m-ethyltoluene
63	139.5	p-ethyltoluene
64	140.5	$C_{10}H_{20}$
64A	141	C_8H_{16}
65	141.5	$C_{11}H_{24}$
66	142	o-ethyltoluene
67	143.5	2,2,4-trimethylheptane
68	144.5	1,3,5-trimethylbenzene
69	146	n-undecane
70	147	m-methyl styrene
71	148	t-butyl benzene
72	148.5	4-ethyl-1-octyn-3-ol (tent.)
73	150	n-dodecane
74	150.5	1-undecene
75	151.5	1,2,3-trimethylbenzene
76	153	m-dichlorobenzene
77	154	n-butylbenzene
78	154	dimethylethylbenzene (isomer)
79	156	o-methylstyrene
80	156.5	p-propyltoluene
81	158	$C_{11}H_{22}$
82	158	C_4-alkyl benzene
83,84	159,160	C_4-alkyl benzenes
85	161	(2-methylpropenyl)benzene
86	161.5	$C_{12}H_{26}$
87	162	1-methylindan
88	162.5	C_5-alkyl benzene

Table 41 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
89	-	unknown
90	165	$C_{12}H_{24}$
91	166	C_4-alkyl benzene
92-94	167,168,168.5	C_5-alkyl benzenes
95	-	
96-98	171.5,172,173	C_5-alkyl benzenes

[a] Resolution was on a 200 ft OV-17 SCOT programmed from 30-220°C @ 4°/min.

Table 42. POLLUTANTS IDENTIFIED IN NIGHT AMBIENT AIR FROM ANAHEIM, CA[a]

Chromatographic Peak No.	Elution Temperature (°C)	Compound
1	50	CO_2
2	-	-
3	55	*n*-pentane
3A	56	trichlorofluoromethane
4	57	pentene isomer
5	58	C_5H_{10}
6	59.5	methylene chloride
7	62	acetone
8	63.5	*n*-hexane
9	66	isopropanol
10	67	C_6H_{12}
11	67.5	C_6H_{14}
11A	68	3-methylpentene (isomer)
12	69.5	chloroform
13	71.5	methylcyclopentane
14	75	1,1,1-trichloroethane
14A	75	3-methyl-*cis*-2-pentene
15	77	benzene
16	77	carbon tetrachloride
17	78.5	2-methylhexane
18	78.5	C_7H_{14}
19	80	C_5H_{10}
20	82	3,3-dimethyl-1-pentene
21	83	1,1-dimethylcyclopentene
22	84	trichloroethylene
22A	84.5	*n*-heptane
23	84.5	3-heptyne
24	89.5	2,5-dimethylhexane
25	93	C_8H_{16}
25A	95	C_6H_{14}
26	96	*n*-propyl acetate

Table 42 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
27	97.5	toluene
28	99	2-methylheptane
29	101	3-methylheptane
30	105.5	2,4-dimethylhexane
31	106	*n*-octane
32	107	tetrachloroethylene
33	111	hexamethylcyclotrisiloxane
34	113	C_7H_{16}
35	114	1,2-dimethylcyclohexane
36	115	*n*-nonane
37	116	2-methyl-1-octene
37A	116.5	chlorobenzene
38	119	ethylbenzene
38A	119.5	3-methyloctane
39	120	*p*-xylene
40	122	*m*-xylene
40A	124	bromoform
40B	124	phenylacetylene
40C	124	cyclooctatetraene
41	125.5	*o*-xylene
42	126.5	4-ethylheptane
43	131	C_9H_{18}
44	132	C_8H_{18}
45	133	isopropylbenzene
46	-	unknown
47	134	C_9H_{18}
48	135	$C_{10}H_{22}$
49	-	unknown
50	138	*n*-propylbenzene
51	140	*m*-ethyltoluene
52	141.5	1,3,5-trimethylbenzene

Table 42 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
53	143	*o*-ethyl toluene
54	145.5	octamethylcyclotetrasiloxane
54A	146	1,2,4-trimethylbenzene
55	147	*n*-decane
55A	147.5	acetophenone
56	150	*m*-dichlorobenzene
57	150.5	*sec*-butylbenzene
58	151	*o*-cymene
59	152	1,2,3-trimethylbenzene
60	153	*m*-cymene
61	155	β-methylstyrene
62	155.5	2,4,4-trimethylhexane
63	156	*m*-diethylbenzene
63A	156.5	*p*-propyl toluene
64	157	C_4-alkyl benzene
65	158	*n*-undecane
66	159	C_4-alkyl benzene
67	159.5	C_9H_{18}
68	160	C_4-alkyl benzene
69	161	C_4-alkyl benzene
70	162	1-methylindan
71	162.5	*m*-*n*-propyltoluene
72	163	5-methyldecene (isomer)
73	164.5	(1-methylbutyl)benzene
73A	165	1-dodecene
74	167	1,2,3,4-tetramethylbenzene
75	167.5	C_5-alkyl benzene
76	169	C_4-alkyl benzene
77	170	$C_{11}H_{20}$
78	170.5	$C_{12}H_{24}$
79	171.5	C_4-alkyl benzene

Table 42 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
80	172	(2-methyl-propenyl)benzene
81	174	C_4-alkyl benzene
82-85	174.5,175,177	C_5-alkyl benzenes

[a] Resolution was on a 200 ft OV-17 SCOT programmed from 30-220°C @ 4°C/min.

Table 43. POLLUTANTS IDENTIFIED OR DETECTED IN AMBIENT AIR FROM SANTA MONICA, CA[a]

Chromatographic Peak No.	Elution Temperature (°C)	Compound
1	-	CO_2
2	77	unknown
3	79	2-methylpropane
4	81	1-butene
5	82	2-butene
6	86	chloroethane
7	88	_n_-butylamine (tent.)
8	91	isopentane
9	92	trichlorofluoromethane
10	93	C_5H_{10}
11	94	_n_-pentane
12	96	cyclopentene
13,14	96,97	pentenes
15	98	methylene chloride
16	100	acetone
17,18	104,106	C_6H_{14} (isomers)
19	110	3-methylpentane
20	111	C_6H_{12}
21	111	C_6H_{14}
22	112	_n_-hexane
23	113	C_6H_{12}
24	115	chloroform
25	117	C_6H_{12}
26	118	methylcyclopentane
27	120	C_6H_{10}
28	121	methyl ethyl ketone
29	122	1,1,1-trichloroethane
30	124	C_7H_{16}
31	124	benzene
32	125	carbon tetrachloride

Table 43 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
33-35	127,128,130	C_7H_{16} (isomers)
36	130	C_7H_{14}
37	131	3-methylhexane
38	131	C_7H_{16}
39	132	C_7H_1
40	133	_n_-heptane
41	135	C_7H_{14}
42	136	dimethylfuran (isomer ?)
43	137	C_7H_{14}
44	138	C_7H_{14}
45	141	C_8H_{18}
46	142	C_7H_{14}
47	144	$C_5H_{16}O$
48,49	146	C_8H_{16} (isomers)
50	146	C_8H_{18}
51	148	toluene
52	150	C_8H_{18}
53,54	153,154	C_8H_{18}
55	154	_n_-octane
56	156	C_8H_{16}
57	157	tetrachloroethylene
58-61	159,160,162,163	C_9H_{20} (isomers)
62	164	C_8H_{16}
63	165	C_9H_{18}
64	165	chlorobenzene
65,66	166,167	C_8H_{18} (isomers)
67	168	ethylbenzene
68	170	C_9H_{18}
69	172	phenylacetylene
70,71	173,174	C_9H_{18} (isomers)

Table 43 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
72	174	o-xylene
73	175	n-nonane
74	178	C_9H_{18}
75,76	179,180	$C_{10}H_{22}$ (isomers)
77	181	isopropylbenzene
78	182	$C_{16}H_{22}$
79	183	C_9H_{18}
80	184	$C_{10}H_{22}$
81	184	$C_{10}H_{20}$
82	186	n-propylbenzene
83	187	m-ethyltoluene
84	189	p-ethyltoluene
85	189	acetophenone
86	190	$C_{10}H_{20}$
87	192	1,3,5-trimethylbenzene
88	192	$C_{10}H_{22}$
89	193	n-decane
90	194	1,2,4-trimethylbenzene
91,92	195,197	$C_{10}H_{20}$
93	197	isobutylbenzene
94	198	$C_{11}H_{24}$
95	198	m-dichlorobenzene
96	200	C_4-alkyl benzene
97	201	1,2,3-trimethylbenzene
98	201	$C_{10}H_{20}$
99	202	$C_{11}H_{24}$
100	203	methylstyrene (isomer ?)
101-103	204,205	C_4-alkyl benzene
104	206	$C_{11}H_{24}$
105-107	207,209	C_4-alkyl benzene

Table 43 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
108,109	210,211	$C_{11}H_{24}$ (isomers)
110,111	212,213	C_4-alkyl benzene
112	214	C_5-alkyl benzene
113-115	214,216,217	C_4-alkyl benzene
116	218	C_5-alkyl benzene
117	219	ethylstyrene (isomer ?)
118	222	unknown
119	227	$C_{12}H_{26}$

[a] Resolution was on a 400 ft OV-101 SCOT programmed from 30-220° C @ 4°C/min.

Table 44. POLLUTANTS IDENTIFIED OR DETECTED IN AMBIENT AIR FROM GLENDORA, CA[a]

Chromatographic Peak No.	Elution Temperature (°C)	Compound
1	86	difluorochloromethane
2	92	1-butene
3	93	isobutane
4	-	unknown
5	-	unknown
6	100.5	isopentane
6A	103	trichlorofluoromethane
7	103.5	1-pentene
7A	104.5	C_5H_8
8	105	n-pentane
9	106	isoprene
10	107	methylene chloride
11	108	propanal
12	109	acetone
13	-	unknown
14	-	unknown
15	115	2-methylpentane
15A	117	2-fluoro-2-methylpropane
16	118.5	3-methylpentane
17	121	C_6H_{12}
18	122	3-methyl-2-pentene + n-hexane
18A	122.5	2-methylfuran
19	123.5	chloroform
20	127.5	C_6H_{14}
21	129	C_6H_{12}
22	129.5	methyl vinyl ketone (tent.)
22A	130	methyl ethyl ketone
23	131.5	1,1,1-trichloromethane
23A	132	ethyl acetate

Table 44 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
24	134	benzene
25	134.5	carbon tetrachloride
26	136	C_6H_{12}
27	137	2,3-dimethylpentane
28	138.5	1,1,3,3-tetramethylcyclopentane
29	140	cyclohexenol isomer
30	-	unknown
31	141.5	1,trans-2-dimethylcyclopentane
31A	142	C_7H_{16}
31B	142	C_7H_{12}
31C	143	trichloroethylene
32	143.5	n-heptane
33	146	C_7H_{12}
34	147	C_6H_{14}
35	148	2,2,3,3-tetramethylbutane
36	149	4,4-dimethyl-2-pentene
37	151.5	2,5-dimethylhexane
38	152	3-heptene
39	154	C_8H_{16}
40	155.5	1-octene
41	157.5	2,3-dimethylhexane
42	158	toluene
43	161	2,4-dimethylhexane
44	162.5	2,2-dimethyl-3-ethylpentane
45	163.5	trimethylcyclopentane isomer
46	165	n-octane
47	167	hexamethylcyclotrisiloxane
48	168	tetrachloroethylene
49	-	unknown

Table 44 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
50	172	2,3,4-trimethylhexane
51	173	C_8H_{16}
52	174.5	C_9H_{20}
53	175	n-butyl acetate
54	176	C_9H_{18}
55	177.5	chlorobenzene
56	179	ethylbenzene
57	181	p-xylene
58	182	m-xylene
59	182.5	2,2,5,5-tetramethylhexane
60	184	C_9H_{18}
61	-	unknown
62	185	C_9H_{20}
63	185	o-xylene
64,65	189,190	$C_{10}H_{22}$ (isomers)
65A	191	C_9H_{18}
66	191.5	$C_{10}H_{22}$
67	192.5	isopropylbenzene
67A	192.5	C_9H_{16}
68	193	2,6-dimethyloctane
69	194.5	$C_{10}H_{20}$
70	195.5	n-propylcyclohexane
71	196	4-ethyl-3-octene
72	-	unknown
73	197	2-methyl-3-ethylheptane
74	197.5	4-methylnonane
75	197.5	5-methyldecane
76	198	n-propylbenzene
77	200	2,6-dimethyloctane
78	201	octamethylcyclotetrasiloxane

Table 44 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
79	201.5	$C_{11}H_{24}$
80	202	*m*-ethyltoluene
81	203	$C_{10}H_{20}$
82	-	unknown
82A	205	*n*-decane
83	205.5	1,3,5-trimethylbenzene
84	-	unknown
85	-	unknown
86	207	isobutylbenzene
87	208	*sec*-butylbenzene
88	209	*m*-dichlorobenzene
89	209.5	$C_{11}H_{24}$
90	210	C_4-alkyl benzene
91	211	1,2,4-trimethylbenzene
92	-	unknown
93	-	unknown
94	213	4-ethyl-1-octyn-3-ol
95	214	*o*-diethylbenzene
96	215.5	*p*-propyltoluene
97	216	*m*-diethylbenzene
95,99	217,218	$C_{11}H_{24}$ (isomers)
100	219	*sec*-butylbenzene
101	221	1,4-dimethyl-2-ethylbenzene
102	221.5	$C_{11}H_{22}$
103	202	1,2-dimethyl-3-ethylbenzene
104	222	*n*-undecane
105	223	C_5-alkyl benzene
106	224	$C_{11}H_{22}$
106A	224	$C_{11}H_{20}$
107	225.5	$C_{12}H_{26}$
107A	226	$C_{11}H_{20}$

Table 44 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
108	226.5	*n*-dodecane
109	227	2,5-dimethyldecane
110	228.5	column background
111	229.5	$C_{11}H_{20}$
111A	229.5	$C_{12}H_{24}$
112	230	$C_{11}H_{20}$
113	230	$C_{12}H_{24}$
113A	230	$C_{12}H_{26}$
114	230	$C_{11}H_{24}$
115	230	$C_{12}H_{26}$
116	230	column background
117	230	$C_{11}H_{24}$
118	230	$C_{12}H_{26}$
119	230	naphthalene

[a] Resolution was on a 400 ft OV-101 SCOT programmed from 20-230°C @ 4°C/min. See Figure 12.

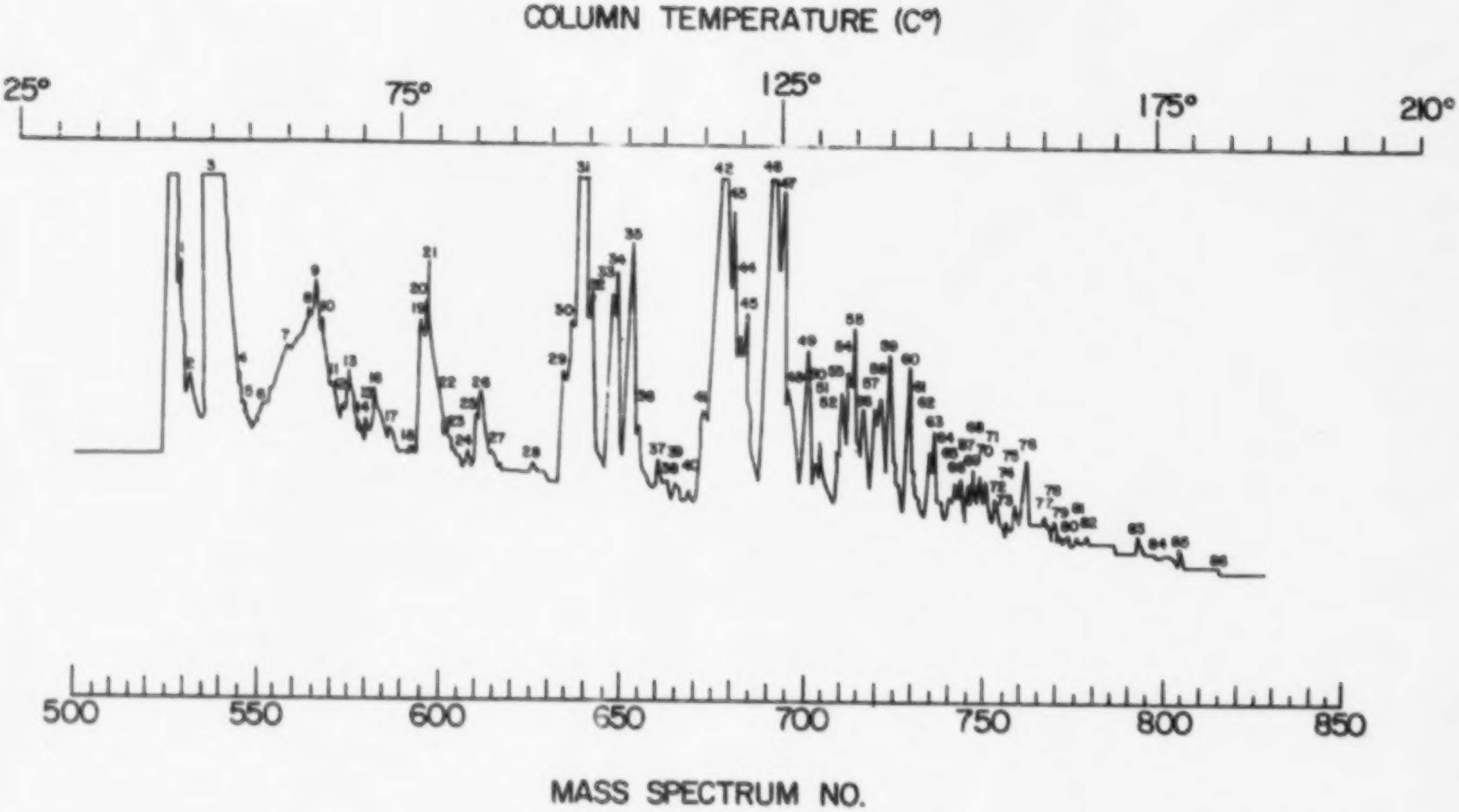

Figure 24. Total ion current plot of ambient air sample taken at May Street, Houston, TX. A 200 ft OV-101 SCOT was used, see text for conditions.

Table 45. POLLUTANTS IDENTIFIED IN AMBIENT AIR FROM MAY STREET IN HOUSTON, TX.

Peak No.[a]	Compound	Peak No.[a]	Compound
1	ethylene oxide		
3	acetone	46	trimethylbenzene isomer
6	n-hexane	48	dichlorobenzene isomer
7	methylcyclopentane	49	trimethylbenzene isomer
8	benzene	51	indan
9	n-butyl vinyl ether	53	methylpropylbenzene isomer
11	trimethylcyclopentane isomer	54	dimethylethylbenzene (isomer ?)
12	cis-2-heptene	56	methyldecane isomer
13	n-heptane	58	diethylbenzene isomer
16	tetramethylcyclopropane isomer	57	methyldecane isomer
21	toluene	58	dimethylethylbenzene (isomer?)
24	octene-1	59	o-cymene
26	n-octane	60	4-phenylbutan-2-one + n-undecane
29	p-xylene	63	tetramethylbenzene isomer
31	m-xylene	65	2-phenyl-2-methylbutane
33	benzonitrile	66	2-methylbenzo-(B)-furan
34	o-xylene	67	methylstyrene
35	3-methyl-2-ethylhexane	69	dimethyldecane isomer
37	isopropylbenzene (cumene)	71	α-cyanopyridine (tent.) + 2-methylundecane + 2-methylbenzimidazole
41	n-propylbenzene		
		73	methylphthalide isomer

Table 45 (cont'd)

Peak No.[a]	Compound	Peak No.[a]	Compound
42,45	C_3-alkylbenzene	76	*n*-dodecane
		83	*n*-tridecane

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[a] See previous Figure.

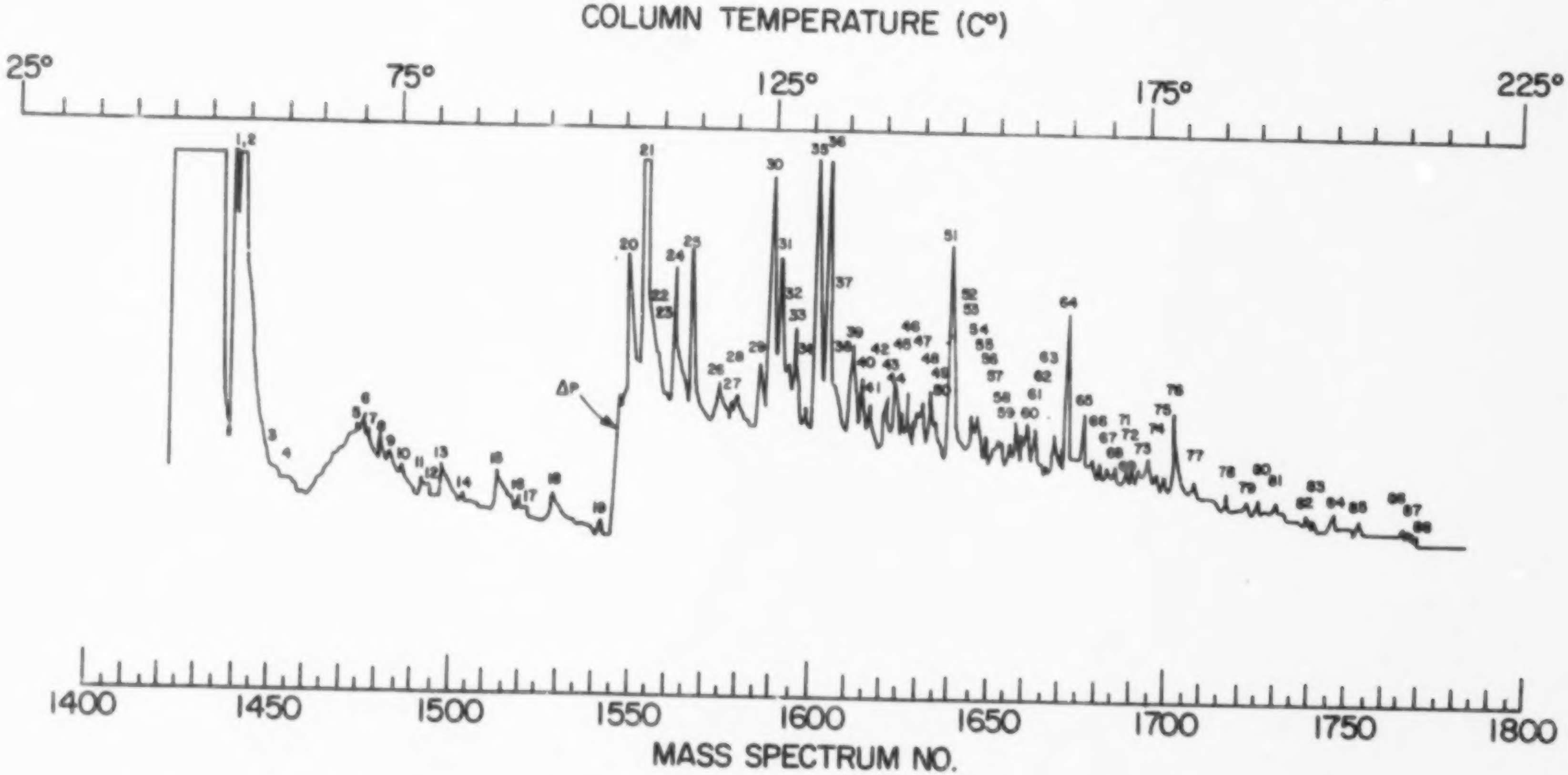

Figure 25. Total ion current plot of ambient air sample taken at Shaw Drive, Pasadena, TX. A 200 ft OV-101 SCOT was used, see text for conditions.

Table 46. POLLUTANTS IDENTIFIED IN AMBIENT AIR FROM PASADENA, TX.[a]

Peak No.	Compound	Peak No.	Compound
2	acetone	21	benzaldehyde + xylene (isomer)
-	chloroform	23	α-cyanopyridine
7	dimethyl pentane	24	xylene (isomer)
8	benzene	25	C_9H_{20}
9	4-methyl-1-pentene	26	1-methyl-3-ethylbenzene
10	2,2-dimethylcyclobutanone	29	*n*-propylbenzene
12	*n*-heptane	32	C_3-alkylbenzene
13	dimethylcyclopentane (isomer) + tetramethylcyclopropane (isomer)	33	$C_{10}H_{22}$ + isopropylbenzene
14	4-methyl-1-hexane	34	$C_{10}H_{20}$
15	toluene	35	C_3-alkylbenzene
18	*n*-octane	63	$C_{20}H_{22}$
20	chlorobenzene + xylene (isomer)	64	*n*-dodecane
36	$C_{10}H_{22}$	76	*n*-tridecane
38	dichlorobenzene (isomer)		
39	trimethylbenzene (isomer) + cymene (isomer)		
40	limonene		
41	methylstyrene (isomer)		
42	*sec*-butylcyclohexane		
43	1,2-diethylbenzene		
44	$C_{11}H_{24}$		

Table 46 (cont'd)

Peak No.	Compound	Peak No.	Compound
50	1,3-diethylbenzene		
53	C_3-alkylbenzene		
58	$C_{12}H_{22}$		
60	$C_{20}H_{24}$		

[a] See previous Figure.

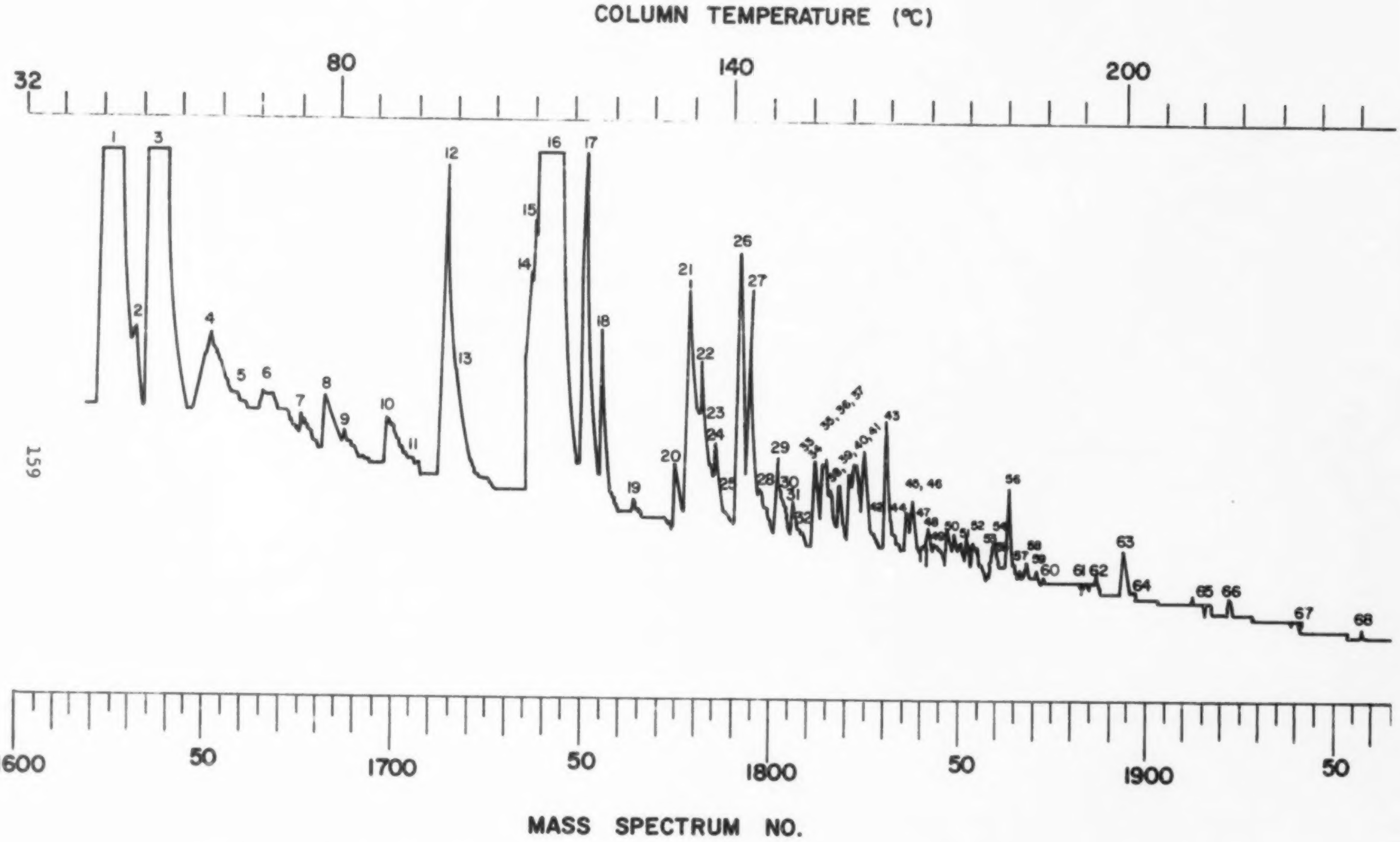

Figure 26. Total ion current of ambient air sample from Baytown, TX. A 200 ft OV-101 SCOT was used, see text for conditions.

Table 47. POLLUTANTS IDENTIFIED IN AMBIENT AIR FROM BAYTOWN, TX[a]

Peak No.	Compound	Peak No.	Compound
1	ethylene oxide + O_2 + N_2 + CO_2	24	methylethylbenzene (isomer)
2	butene isomer + n-pentane	26	trimethylbenzene (isomer)
3	acetone	27	n-decane
5	4-methyl-1-pentene	28	dichlorobenzene (isomer)
-	benzene	31	methylstyrene (isomer)
-	cis-1,3-dimethylcyclopentane	33	diethylbenzene (isomer)
7	n-heptane	34	sec-butylbenzene
8	2,4-dimethyl-2-pentene	38	acetophenone
10	toluene	40	diethylbenzene (isomer)
12	tetrachloroethylene	50	ethylstyrene (isomer)
14	chlorobenzene	53	naphthalene
16	xylene (isomer)	56	n-dodecane
17	dimethylethylpentane (isomer)		
18	xylene (isomer)		
19	methylethylbenzene (isomer)		
20	phenylacetaldehyde		
21	methylethylbenzene (isomer)		
22	trimethylbenzene (isomer)		

[a] See previous Figure.

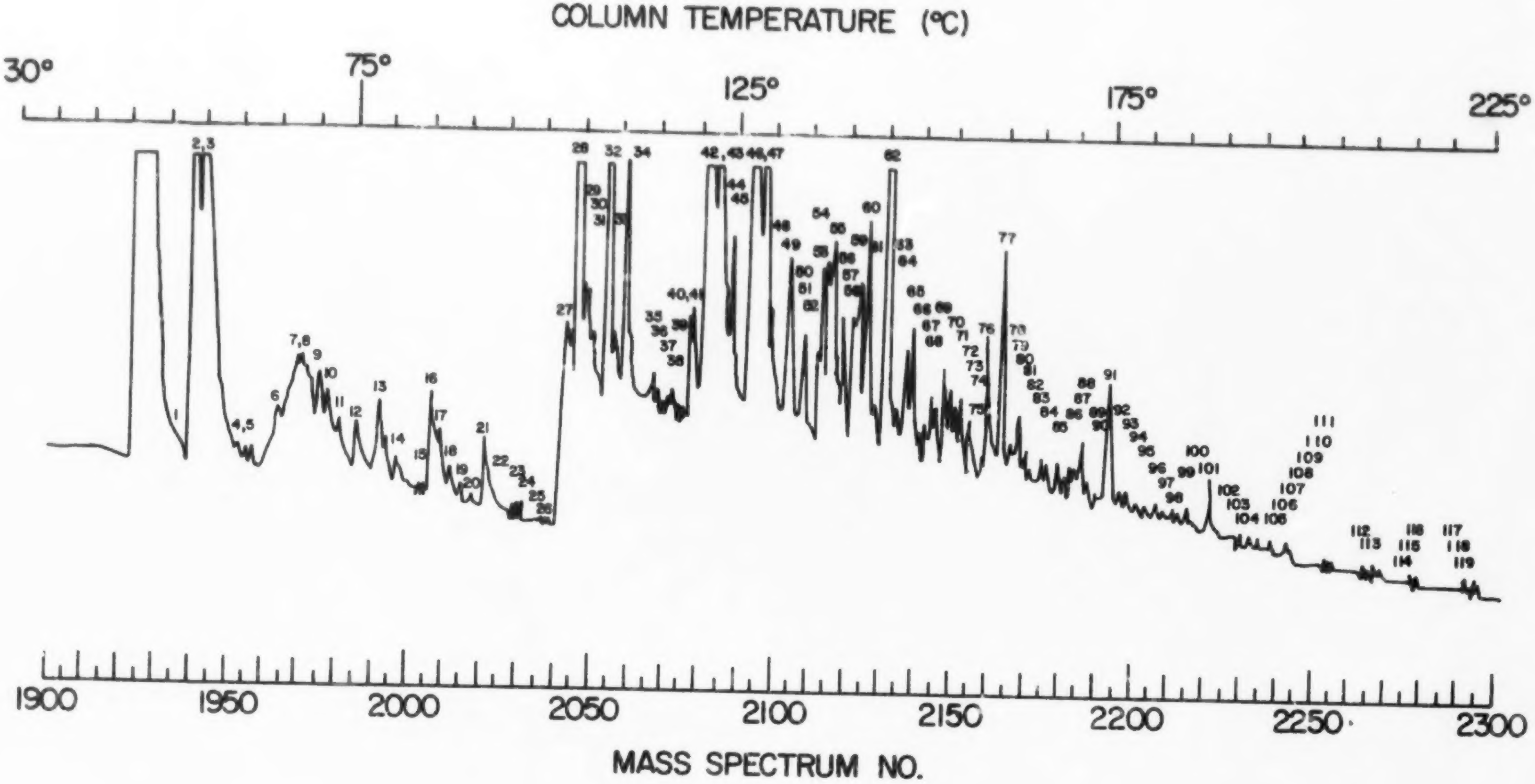

Figure 27. Total ion current plot of ambient air sample taken in Texas City, TX. A 200 ft OV-101 SCOT was used, see text for conditions.

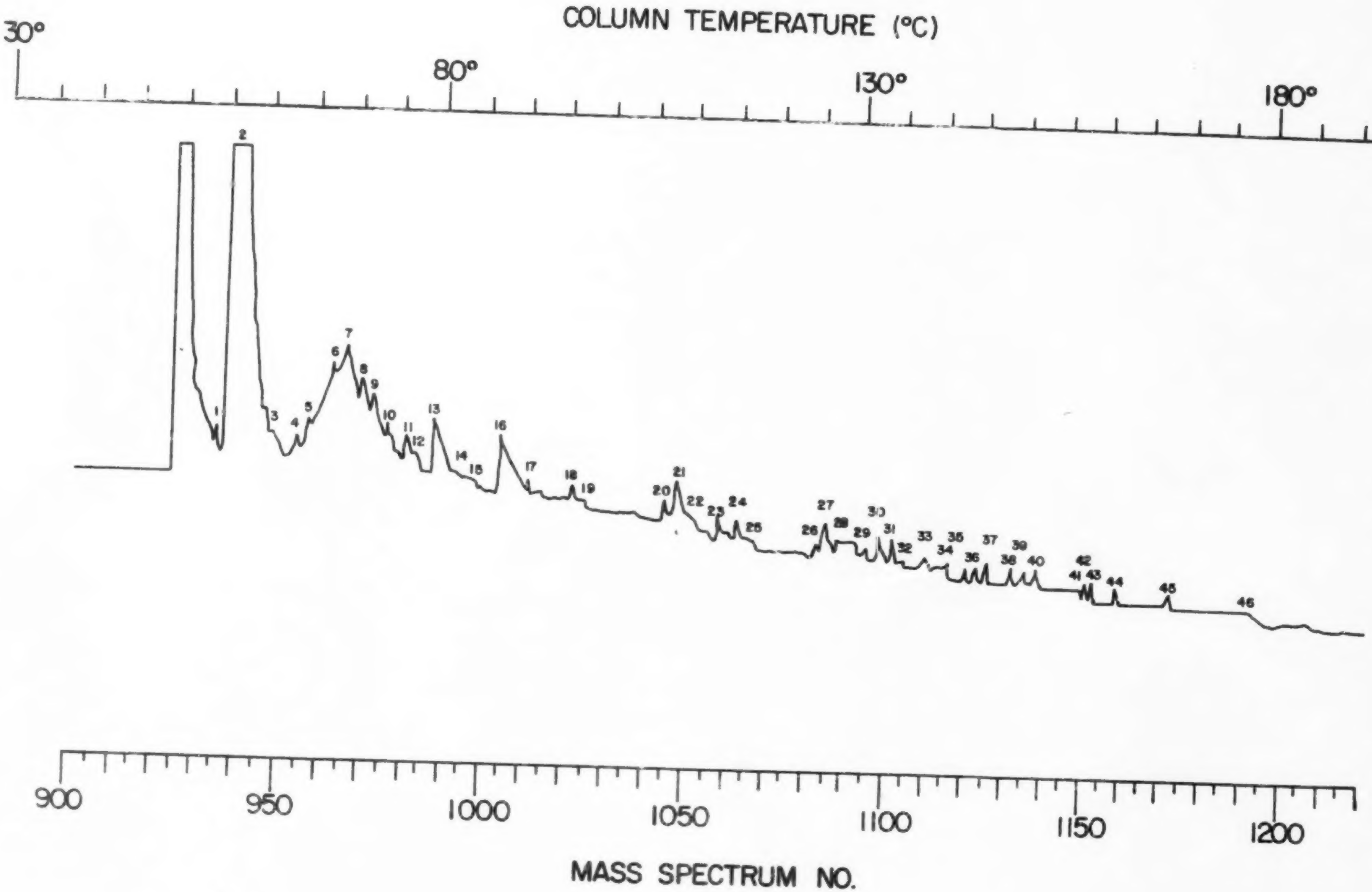

Figure 28. Total ion current plot of ambient air sample taken at Stuebner Airline, Houston, TX. A 200 ft OV-101 SCOT was used, see text for conditions.

Table 48. POLLUTANTS IDENTIFIED IN AMBIENT AIR FROM PASADENA, TX[a]

Chromatographic Peak No.	Elution Temperature (°C)	Compound
1	53	2-methylpropane
2	54	2-methylpropene
3	56	2-methylbutane
4	57	n-pentane
5	60	ethanol (tent.)
6	61	furan (tent.)
7	61	2-methylpentane
8	64	acetone
8A	64	methylene chloride
9	68	methylcyclopentane
10	70	3,3-dimethylpentane
11,12	70,71	C_7H_{16} (isomers)
13	73	C_7H_{14} + C_7H_{16}
14	75	C_7H_{16}
14A	75	chloroform
15	77	carbon tetrachloride
16	78	ethyl acetate
17	80	C_8H_{18}
18	80	C_8H_{16}
19	81	benzene
20	83	C_7H_{14}
20A	83	C_8H_{16}
21	84	C_7H_{14}
22,23	85,6	C_8H_{18} (isomers)
24	87	trichloroethylene
24A,25	87,9	C_8H_{18} (isomers)
26,27	89,91	C_8H_{16}
28	92	C_8H_{18}
28A	92	C_8H_{16}
29	94	C_8H_{16}

Table 48 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
30	94	hexamethylcyclotrisiloxane
31,32	95,6	C_9H_{20} (isomers)
33	97	C_8H_{16}
34	98	C_9H_{20}
35	99	C_8H_{16}
36	100	C_9H_{20}
37	101	C_9H_{18}
37A	101	toluene
38,39	101,4	C_9H_{18} (isomers)
39A,40	104,6	C_9H_{20} (isomers)
41	107	tetrachloroethylene
42	108	C_9H_{18}
42A	108	methyl isobutyl ketone (tent.)
43	110	C_9H_{20}
44	114	C_9H_{16}
44A	114	C_9H_{18}
44B-47	114-117	C_9H_{22} (isomers)
48	118	C_9H_{20}
49	119	ethylbenzene
50	120	p-xylene
50A	120	chlorobenzene
50B	120	octamethylcyclotetrasiloxane
51,52	121,2	$C_{10}H_{22}$ (isomers)
53	123	$C_{11}H_{24}$
54	124	$C_{10}H_{22}$
55	124	α-phellandrene (tent.)
56	126	m-xylene
56A	126	phenylacetylene
57	128	styrene
57A	128	$C_{10}H_{22}$
58	130	isopropylbenzene

Table 48 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
59	131	$C_{10}H_{20}$
60	132	$C_{11}H_{24}$
61	133	C_4-alkyl benzene
61A	133	$C_{11}H_{24}$
61B	133	$C_4H_2Cl_4$
62	134	$C_{10}H_{20}$
62A,63	134,5	$C_{11}H_{24}$ (isomers)
63A	135	bromoform
64	136	n-propylbenzene
65,66	137	$C_{12}H_{26}$
67	137	m-ethyltoluene
68	139	1,3,5-trimethylbenzene
69-71	139-41	$C_{11}H_{24}$ (isomers)
72	142	p-ethyltoluene
73	144	$C_{12}H_{24}$
74	144	o-ethyltoluene
74A	144	limonene
75	146	C_4-alkyl benzene
75A	146	$C_{11}H_{24}$
76	148	C_4-alkyl benzene
77,78	149,150	$C_{12}H_{26}$
79	151	trimethylbenzene (isomer)
79A	152	$C_{12}H_{24}$
80	153	C_4-alkyl benzene
80A	153	dichlorobenzene (isomer)
81,81A	153	C_4-alkyl benzenes
82	154	$C_{12}H_{26}$
82A	154	p-methylanisole
83	155	$C_{12}H_{16}$
84	156	indan
85	156	C_4-alkyl benzene

Table 48 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
86	157	$C_{11}H_{22}$
87	158	C_4-alkyl benzene
87A	158	dichlorobenzene (isomer)
88,89	159,160	C_4-alkyl benzene
89A,90	160,1	C_5-alkyl benzenes
90A	161	$C_{13}H_{26}$
91	162	$C_{12}H_{26}$
91A	162	β,β-dimethyl styrene
91B	162	C_5-alkyl benzene
92,93	163,4	$C_{13}H_{28}$
93A	164	C_5-alkyl benzene
94	165	$C_{13}H_{28}$
94A,95	165	C_4-alkyl benzenes
95A	165	$C_{13}H_{28}$
96	167	C_5-alkyl benzene
96A	167	C_4-alkyl benzene
96B	167	$C_{12}H_{24}$
97	168	C_5-alkyl benzene
97A	168	$C_{12}H_{24}$
98,99	168,9	C_5-alkyl benzene
100	170	$C_{13}H_{28}$
100A,101	170,171	C_5-alkyl benzenes
102	171	$C_{14}H_{30}$
102A,103	171,172	C_5-alkyl benzene
103A	172	5-methylindan (tent.)
104	173	C_5-alkyl benzene
104A	173	C_6-alkyl benzene
105	173	C_4-alkyl benzene
105A	173	C_5-alkyl benzene
106	174	$C_{13}H_{26}$
106A	174	C_6-alkyl benzene

Table 48 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
107	175	C_7-alkyl benzene
108	177	$C_{13}H_{26}$
108A	177	$C_{13}H_{28}$
109,110,111	178,9	C_5-alkyl benzenes
111A	179	$C_{14}H_{28}$ (tent.)
112	180	$C_{13}H_{26}$
113	181	C_6-alkyl benzene
114	182	C_6-alkyl benzene
114A	183	$C_{13}H_{26}$
115	183	C_6-alkyl benzene
116-118	184-6	unknowns
119	187	naphthalene

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[a] Resolution was on a 200 ft OV-17 SCOT column; 30-220° @ 4°/min.

Table 49. POLLUTANTS IDENTIFIED IN AMBIENT AIR FROM BAYTOWN, TX[a]

Chromatographic Peak No.	Elution Temperature (°C)	Compound
1	52	2-methylpropane
2	53	2-methylpropene
3	57	2-methylbutane
4	58	*n*-pentane
5	61	acetaldehyde
6	63	furan
6A	63	2-methylpentane
7	65	acetone
8	66	methylene chloride
9	70	methylcyclopentane
10	72	3,3-dimethylpentane
10A,11	72,73	C_7H_{16}
12	75	C_7H_{14}
13	77	C_7H_{16}
13A	77	C_7H_{14}
14	77	carbon tetrachloride
14A	80	C_8H_{18}
15	80	ethyl acetate
16,17	82	C_8H_{18} (isomers)
18	82	C_8H_{16}
19	84	benzene
19A	84	C_7H_{14}
20	86	C_8H_{16}
21,22	87,88	C_8H_{18} (isomers)
23	88	trichloroethylene
23A,24	88,89	C_8H_{18} (isomers)
25-27	90,92,93	C_8H_{16} (isomers)
27A	93	C_8H_{18}
28	96	C_8H_{16}
29	96	hexamethylcyclotrisiloxane

Table 49 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
30	96	C_8H_{16}
31	97	C_9H_{20}
32	97	C_8H_{16}
33	100	C_8H_{16}
34	100	C_9H_{20}
35	100	C_9H_{18}
36	102	toluene
37	103	C_9H_{18}
38,38A,39	104,105,106	C_9H_{20} (isomers)
39A	106	$C_{10}H_{22}$
40	107	tetrachloroethylene
40A	109	C_9H_{18}
41,42	112	C_9H_{20}
43	114	C_9H_{18}
44-47	115,116,117,118	$C_{10}H_{22}$ (isomers)
48	120	ethylbenzene
49	122	$C_{10}H_{22}$
50	123	$C_{11}H_{24}$
51	124	$C_{10}H_{22}$
52	126	_p_-xylene
53	128	$C_{10}H_{22}$
53A	128	$C_{10}H_{20}$
54	130	isopropylbenzene
54A	130	$C_{10}H_{20}$
55-57	131,132,133	$C_{11}H_{24}$ (isomers)
58,59	133,134	$C_{11}H_{22}$ (isomers)
60	135	_n_-propylbenzene
61	136	$C_{12}H_{26}$
62	137	_m_-ethyltoluene
63	137	_p_-ethyltoluene
64	138	1,3,5-trimethylbenzene

Table 49 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
65	138	$C_{11}H_{24}$
66	139	$C_{12}H_{24}$
67	140	$C_{11}H_{22}$
68	141	C_3-alkyl benzene
69	142	hexamethylcyclopentasiloxane
70	143	1,2,4-trimethyl benzene
70A	143	$C_{12}H_{26}$
71	145	$C_{11}H_{24}$
72	145	$C_{11}H_{22}$
73	146	C_4-alkyl benzene
74	147	$C_{12}H_{26}$
75	148	unknown
76	150	1,2,3-trimethylbenzene
77	152	C_4-alkyl benzene
78	152	dichlorobenzene (isomer)
78A	152	C_4-alkyl benzene
79	153	C_4-alkyl benzene
79A	153	$C_{12}H_{26}$
80	155	indan
81	155	C_4-alkyl benzene
82	157	$C_{12}H_{26}$
82A	157	$C_{12}H_{24}$
83	158	C_4-alkyl benzene
84	159	C_4-alkyl benzene
85	160	C_4-alkyl benzene
86	161	$C_{12}H_{26}$
87	162	1-methylindan (tent.)

[a] Resolution was on a 200 ft OV-17 SCOT column programmed from 30-220° @ 4°/min.

Table 50. POLLUTANTS IDENTIFIED IN AMBIENT AIR FROM TEXAS CITY, TX[a]

Chromatographic Peak No.	Elution Temperature (°C)	Compound
2	51	2-methylpropene
3	53	2-methylbutane
4	54	n-pentane
4A	54	C_5H_{10}
5	56	ethanol (tent.)
6	57	furan (tent.)
7	58	2-methylpentane
8	59	acetone
8A	60	methylene chloride
9	64	methylcyclopentane
10,11	65,67	C_7H_{16} (isomers)
12	69	C_7H_{14}
13	71	C_7H_{16}
13A	71	C_7H_{14}
13B	71	chloroform
14	73	C_7H_{16}
15	73	ethyl acetate
15A	73	carbon tetrachloride
16-16A,17	75	C_8H_{18} (isomers)
17A	75	C_8H_{16}
18	75	benzene
19	78	C_7H_{14}
19A,20	78,80	C_8H_{16} (isomers)
21,22	81,3	C_8H_{18}
22A	83	trichloroethylene
23,24	84,86	C_8H_{16}
25	88	C_8H_{18}
25A	88	C_8H_{18}
26	88	C_8H_{18}
26A	88	C_8H_{16}

Table 50 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
27	90	hexamethylcyclotrisiloxane
27A	90	C_8H_{18}
27B,28	90,1	C_8H_{16} (isomers)
28A	91	C_9H_{20}
29	92	C_8H_{16}
29A	92	C_9H_{20}
30	93	C_8H_{16}
30A,31	93,4	C_9H_{20} (isomers)
32	96	C_8H_{16}
32A	96	C_9H_{20}
33	97	toluene
34	99	C_9H_{18}
35	100	C_9H_{20}
36	102	C_9H_{20}
37	104	tetrachloroethylene
38	105	C_9H_{18}
39	106	methyl isobutyl ketone
40	107	C_9H_{20}
41	111	C_9H_{18}
42	111	$C_{10}H_{22}$
43,44	113,4	$C_{10}H_{22}$ (isomers)
45,46	114,6	$C_{10}H_{22}$
46	116	C_9H_{18}
46A	116	iso-amyl acetate (tent.)
47	117	ethylbenzene
48	118	*p*-xylene
48A	118	octamethylcyclotetrasiloxane
49	120	$C_{10}H_{22}$
50	121	$C_{11}H_{24}$
51	122	$C_{10}H_{22}$
52	124	*m*-xylene

Table 50 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
53	126	phenylacetylene
53A	126	styrene
53B	127	$C_{10}H_{22}$
53C	128	$C_{10}H_{20}$
54	128	isopropylbenzene
55	129	$C_{10}H_{20}$
56-8	130-2	$C_{11}H_{24}$ (isomers)
59	133	$C_{11}H_{22}$
60	134	bromoform
60A	134	*n*-propylbenzene
61	135	$C_{11}H_{22}$
62	136	$C_{12}H_{24}$
62A	136	*m*-ethyltoluene
63	137	1,3,5-trimethylbenzene
64,65,66	138,140	$C_{11}H_{24}$ (isomers)
67	141	*o*-ethyl toluene
68	143	1,2,4-trimethylbenzene
69	145	*sec*-butyl benzene
69A	145	$C_{11}H_{24}$
70	146	*o*-cymene (tent.)
71	147	*m*-cymene (tent.)
72	147	$C_{12}H_{26}$
73	149	$C_{10}H_{18}$
74	150	1,2,3-trimethylbenzene
75	152	C_4-alkyl benzene
76	152	dichlorobenzene (isomer)
77	152	C_4-alkyl benzene
78	153	C_4-alkyl benzene
78A	153	$C_{12}H_{26}$
79	155	indan
80	156	C_4-alkyl benzene

Table 50 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
81-4	157-160	C_4-alkyl benzenes
84A	161	C_5-alkyl benzene
85	161	$C_{12}H_{26}$
86	162	C_5-alkyl benzene
87	163	1-methylindan
87A	163	$C_{12}H_{26}$
88,89	165	C_4-alkyl benzenes
89A	165	$C_{13}H_{28}$
90	166	C_4-alkyl benzene
90A	166	C_5-alkyl benzene
90B	166	$C_{12}H_{24}$
91	167	C_5-alkyl benzene
92	168	$C_{11}H_{24}$
92A	168	$C_{13}H_{28}$
92B-95	168-170	C_5-alkyl benzenes
95A	170	$C_{13}H_{28}$
95B	170	$C_{13}H_{26}$
96	171	$C_{14}H_{30}$
96A	171	C_5-alkyl benzene
97	172	2-methylindan (tent.)
98	172	C_5-alkyl benzene
98A	172	C_6-alkyl benzene
98B	172	$C_{13}H_{28}$
99	173	C_5-alkyl benzene
100	174	4 (or 5)-methylindan
101	176	$C_{13}H_{28}$
102	177	C_5-alkyl benzene
103	178	C_5-alkyl benzene
104	179	$C_{13}H_{28}$
104A	179	C_6-alkyl benzene
105	180	C_5-alkyl + C_6-alkyl benzene

Table 50 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
106	181	C_6-alkyl benzene + $C_{13}H_{26}$
107	182	C_6-alkyl benzene + $C_{13}H_{26}$
108	184	unknown
109	185	C_6-alkyl benzene
110	186	unknown
111	186	napthalene
112	188	C_6-alkyl benzene
113	189	C_5H_9-benzene
113A	189	C_6-alkyl benzene
114	191	$C_{14}H_{30}$

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[a] Resolution was on a 200 ft OV-17 SCOT column; 30-220° @ 4°/min.

Table 51. POLLUTANTS IDENTIFIED IN AMBIENT AIR FROM PASADENA, TX[a]

Chromatographic Peak No.	Elution Temperature (°C)	Compound
1	75	propene
2	76	SO_2
3	77	chloromethane
4	78	2-methylpropane
4A	78	vinyl chloride
5	80	2-methylpropene
5A	80	n-butane
6	85	ethyl chloride
6A	85	acetaldehyde
6B	85	tetramethylsilane (tent.)
7	90	n-pentane
7A	90	acetone
8	95	methylene chloride
9	97	isopropanol
10	103	2-methylpentane
11	106	3-methylpentane
12	108	C_6H_{12}
13	110	n-hexane
13A	110	2-methylfuran (tent.)
14	112	chloroform
15	115	C_7H_{16}
16	116	C_6H_{12}
17	116	ethyl acetate
17A	120	1,1,1-trichloroethane
18	122	3,3-dimethylpentane
19	123	benzene
19A	123	carbon tetrachloride
20-23	123,124,125,126	C_7H_{16} (isomers)
24,25	128	C_7H_{14} (isomers)

Table 51 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
26	130	trichloroethylene
26A	131	C_7H_{16}
27	137	C_7H_{14}
28,29	138,139	C_8H_{18} (isomers)
30	139	C_7H_{14}
31	141	C_8H_{16}
31A	141	dimethyl disulfide
32,33	143	C_8H_{16}
33A	143	C_8H_{14}
34	144	methyl isobutyl ketone
35	145	C_8H_{18}
35A	146	toluene
36	148	C_8H_{18}
37	150	1-*trans*-*cis*-4-trimethylcyclopentane
38,39,40	150,151,152	C_8H_{16} (isomers)
41	153	C_8H_{18}
42	155	C_8H_{16}
43	156	hexamethyltrisiloxane
44	156	tetrachloroethylene
44A	157	C_8H_{16}
45,46	158	C_9H_{20} (isomers)
47	160	C_9H_{18}
48	162	C_9H_{20}
49,50	162,164	C_9H_{18} (isomers)
51	164	chlorobenzene
52	166	C_9H_{20}
53	166	ethylbenzene
54	167	*p*-xylene
55	168	*m*-xylene
56	171	phenylacetylene

Table 51 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
57	171	$C_{10}H_{22}$
57A	171	2,5-diethylfuran (tent.)
58	172	$C_{10}H_{22}$
59	173	styrene
60	173	*o*-xylene
61	174	C_9H_{20}
62-64	177,178,179	$C_{10}H_{22}$ (isomers)
65	180	isopropylbenzene
65A	180	1,2,3,3-tetrachloropropene
66	181	$C_{10}H_{22}$
67	182	C_9H_{18}
67A	182	$C_{10}H_{22}$
68	183	α-pinene
68A	184	$C_{10}H_{20}$
69	185	$C_{10}H_{22}$
69A	185	*n*-propylbenzene
70	186	$C_{10}H_{22}$
71	186	*m*-ethyltoluene
72	186	$C_{11}H_{24}$
73	188	1,3,5-trimethylbenzene
74	189	$C_{11}H_{24}$
75	189	$C_{11}H_{24}$
76	190	*o*-ethyltoluene
77	191	$C_{10}H_{20}$
78	192	$C_{10}H_{22}$
78A	192	1,2,4-trimethylbenzene
79	194	$C_{10}H_{22}$
80,81	195,196	$C_{11}H_{24}$ (isomers)
81A	196	isobutylbenzene
82	196	$C_{11}H_{24}$
82A	196	*sec*-butylbenzene

Table 51 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
83	197	$C_{11}H_{24}$
83A	197	m-dichlorobenzene
83B	197	o-cymene
84	199	$C_{11}H_{24}$
84A	199	1,2,3-trimethylbenzene
84B	199	m-cymene
85	200	$C_{11}H_{24}$
85A	200	limonene
86	200	$C_{11}H_{24}$
87	201	$C_{10}H_{20}$
88	202	indan
89	203	p-cymene
89A	203	$C_{11}H_{24}$
90	203	m-diethylbenzene
90A	203	$C_{12}H_{26}$
91	204	m-propyltoluene
91A	204	n-butylbenzene
91B	204	p-propyltoluene
92	204	$C_{12}H_{26}$
93	206	$C_{11}H_{24}$
94	206	o-propyltoluene
95	207	$C_{12}H_{24}$
96,97	208,209	C_4-alkyl benzene
97A	210	$C_{11}H_{24}$
98	211	C_5-alkyl benzene
99	212	$C_{12}H_{21}$
99A	212	C_5-alkyl benzene
100	213	$C_{12}H_{26}$
100A	213	C_5-alkyl benzene
100B	213	C_4-alkyl benzene
101	214	$C_{12}H_{26}$

Table 51 (cont'd)

Chromatographic Peak No.	Elution Temperature (°C)	Compound
102	215	C_4-alkyl benzene + C_5-alkyl benzene + $C_{12}H_{26}$
103	216	C_4-alkyl benzene
104	218	C_5-alkyl benzene
105	219	$C_{11}H_{22}$
105A	219	C_5-alkyl benzene
106	219	$C_{12}H_{26}$
107	220	C_5-alkyl benzene + $C_{12}H_{26}$
108	221	$C_{12}H_{26}$
109	222	C_6-alkyl benzene + $C_{12}H_{26}$
110	225	unknown
111	226	$C_{12}H_{26}$
112	229	$C_{13}H_{28}$
112A	229	naphthalene
115	230	$C_{13}H_{28}$

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[a] Resolution was on a 400 ft OV-101 SCOT programmed from 30-230°C @ 4°C/min.

Table 52. POLLUTANTS IN AMBIENT AIR FROM DUNBAR, W VA[a]

Peak No.	RRT	Compound	Peak No.	RRT	Compound
1	0.482	N_2	24	2.130	C_9 branched alkane
2	0.490	CO_2	25	2.190	*m*-xylene
3	0.713	$CFCl_3$	26	2.230	*o*-xylene
4	0.740	methylene chloride	27	2.320	methylethylbenzene (isomer)
5	0.767	acetone			
6	0.896	hexane	28	2.400	C_9 branched alkane
7	1.000	methyl ethyl ketone	29	2.450	*n*-propylbenzene
8	1.030	chloroform	30	2.480	methylethylbenzene (isomer)
9	1.200	benzene			
10	1.240	dimethylpentene	31	2.490	C_{10} branched alkane
11	1.270	methylhexane (isomer)	32	2.500	benzaldehyde
			33	2.520	unknown
12	1.320	heptane (isomer ?)	34	2.536	2,6-dimethyloctane
13	1.360	*n*-heptane	35	2.555	acetophenone
14	1.455	dimethylpentene (isomer)	36	2.630	trimethylbenzene (isomer)
15	1.520	*n*-octane	37	2.650	*n*-decane
16	1.590	1-octene	38	2.715	dichlorobenzene (isomer)
17	1.640	toluene			
18	1.690	epoxyheptane	39	2.740	C_4-alkyl benzene
19	1.810		40	2.750	diethylbenzene (isomer)
20	1.830		41	2.800	methylstyrene (isomer)
21	1.920				
22	2.050	ethylbenzene	42	2.815	C_{11} branched alkane + chlorinated aromatic
23	2.100	*p*-xylene			

Table 52 (cont'd)

Peak No.	RRT	Compound	Peak No.	RRT	Compound
43	2.845	diethylbenzene (isomer)	60	3.280	C_5-alkyl benzene
44	2.870	methyl-n-propyl-benzene	61	3.295	C_5-alkyl benzene
45	2.885	methyldecane (isomer)	62	3.360	trichlorobenzene (isomer)
46	2.910	diethylbenzene (isomer)	63	3.380	C_{12} branched alkane
47	2.920	C_{11} branched alkane	64	3.400	naphthalene
48	2.945	C_2-alkyl benzene	65	3.415	C_5-alkyl benzene
49	2.955	C_2-alkyl benzene	66	3.450	C_{11} branched alkane
50	2.980	C_2-alkyl benzene	67	3.540	C_{13} branched alkane
51	3.030	n-undecane	68	3.585	n-tridecane
52	3.075	dimethylethyl benzene (isomer)	69	3.610	methylnaphthalene (isomer ?)
53	3.110	dimethylethyl-benzene (isomer)	70	3.655	unknown
54	3.130	methylisopropyl-benzene (isomer)	71	3.730	unknown
55	3.140	C_{12} branched alkane	72	3.800	n-tetradecane
56	3.175	C_5-alkyl benzene			
57	3.205	C_5-alkyl benzene			
58	3.240	C_5-alkyl benzene			
59	3.260	n-dodecane			

[a] Resolution was on a 200 ft OV-101 SCOT programmed from 30-200°C @ 4°C/min.

Table 53. POLLUTANTS IN AMBIENT AIR FROM SOUTH CHARLESTON, W VA[a]

Peak No.	RRT	Compound	Peak No.	RRT	Compound
1	0.520	N_2	23	2.262	p-xylene
2	0.530	CO_2	24	2.275	unknown
3	0.736	$CFCl_3$	25	2.335	m-xylene
4	0.735	unknown	26	2.340	unknown
5	0.784	diethyl ether	27	2.372	o-xylene
6	0.813	methylene chloride	28	2.432	unknown
7	0.922	acetone	29	2.470	unknown
8	1.000	methyl ethyl ketone	30	2.490	methylethylbenzene (isomer)
9	1.030	chloroform			
10	1.245	benzene	31	2.530	unknown
11	1.273	unknown	32	2.590	unknown
12	1.322	unknown	33	2.618	n-propylbenzene
13	1.394	unknown	34	2.655	methylethylbenzene (isomer)
14	1.432	n-heptane	35	2.690	methylethylbenzene (isomer)
15	1.530	dimethylpentane (isomer)	36	2.710	2,6-dimethyloctane + benzaldehyde
16	1.600	unknown			
17	1.725	toluene	37	2.745	acetophenone
18	1.785	dimethylhexane (isomer)	38	2.770	trimethylbenzene (isomer)
19	1.920	n-octane	39	2.790	
20	1.960	tetrachloroethylene	40	2.825	n-decane
21	2.040	unknown	41	2.870	C_4-benzene
22	2.195	ethylbenzene	42	2.920	

Table 53 (cont'd)

Peak No.	RRT	Compound	Peak No.	RRT	Compound
43	2.920	C_4-benzene	61	3.260	*n*-undecane
44	2.940	diethylbenzene (isomer)	62	3.285	unknown
45	2.960		63	3.342	unknown
46	2.990	methylstyrene (isomer)	64	3.340	unknown
47	3.000		65	3.342	unknown
48	3.020	diethylbenzene (isomer)	66	3.361	unknown
49	3.050	1-methyl-2-*n*-propyl benzene	67	3.395	unknown
50	3.070	dimethylethylbenzene (isomer)	68	3.410	unknown
51	3.075	C_{11} alkane + diethylbenzene (isomer)	69	3.421	methylvinylbenzene
52	3.090	unknown	70	3.440	unknown
53	3.110	unknown	71	3.450	C_5-alkyl benzene
54	3.120	unknown	72	3.470	C_{12}-alkane
55	3.140	unknown	73	3.500	unknown
56	3.155	dimethylethylbenzene (isomer)	74	3.510	trichlorobenzene
57	3.175	unknown	78	3.600	unknown
58	3.200	unknown	79	3.610	naphthalene
59	3.210	unknown	80	3.630	unknown
60	3.235	unknown	81	3.665	unknown
			82	3.690	unknown
			83	3.710	unknown
			84	3.730	unknown
			85	3.765	unknown
			86	3.790	unknown

Table 53 (cont'd)

Peak No.	RRT	Compound	Peak No.	RRT	Compound
87	3.820	unknown	96	4.020	methylnaphthalene (isomer ?)
88	3.845	unknown	97	4.050	unknown
89	3.865	unknown	98	4.080	methylnaphthalene (isomer ?)
90	3.890	unknown	99	4.120	unknown
91	3.900	unknown	103	4.250	unknown
92	3.920	unknown	104	4.330	n-tetradecane
93	3.940	unknown	105	4.520	unknown
94	3.955	unknown	106	4.660	unknown
95	3.990	n-tridecane			

[a] Resolution was on a 200 ft OV-101 SCOT programmed from 30-220°C @ 4°C/min, see Figure 8.